Minerals Yearbook
1968

Volume I—II

METALS, MINERALS, AND FUELS

U.S. DEPARTMENT OF THE INTERIOR
March 3, 1849

Prepared by staff of the
BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR • Walter J. Hickel, Secretary

BUREAU OF MINES • John F. O'Leary, Director

Created in 1849, the Department of the Interior—America's Department of Natural Resources—is concerned with the management, conservation, and development of the Nation's water, wildlife, mineral, forest, and park and recreational resources. It also has major responsibilities for Indian and Territorial affairs.

As the Nation's principal conservation agency, the Department works to assure that nonrenewable resources are developed and used wisely, that park and recreational resources are conserved for the future, and that renewable resources make their full contribution to the progress, prosperity, and security of the United States—now and in the future.

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON : 1969

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price $6.25 (case bound)

Foreword

The 1968 Minerals Yearbook provides a record of performance of the world's minerals industries during the year of review, with sufficient background information to interpret the year's developments.

Volume I–II, Metals, Minerals, and Fuels, contains chapters on the metal, nonmetal, and mineral fuel commodities essential to the domestic economy. In addition, it includes a general review chapter on these industries, a statistical summary, and chapters on employment and injuries, and technologic trends.

Volume III, Area Reports: Domestic, contains chapters covering each of the 50 States, the U.S. island possessions in the Pacific Ocean and the Caribbean Sea, the Commonwealth of Puerto Rico, and the Canal Zone. This volume also has a statistical summary chapter, identical with that in Volume I–II, and a chapter on employment and injuries.

Volume IV, Area Reports: International, presents the latest available mineral statistics for more than 130 foreign countries and areas and discusses the importance of minerals to the economies of these nations. A separate chapter reviews minerals and their relationship to the world economy.

The Minerals Yearbook is the most comprehensive publication of its kind available and the Bureau will continue its efforts in the years ahead to increase the Yearbook's value to its many users. Toward that end, the constructive comments and suggestions of readers are invited.

JOHN F. O'LEARY, *Director*

REC'D 22 AP 70

Acknowledgments

This volume results essentially from the cooperative effort of the Mineral Resource Evaluation staff of the Bureau of Mines, both in the headquarters and field offices. All chapters in this volume were prepared in this activity except for the Injury Experience and Worktime and Helium chapters, for which the cooperation of the Health and Safety and Helium activity staffs, respectively, is gratefully acknowledged.

Statistics on the domestic minerals and mineral fuels industries were collected and compiled by the Division of Statistics. These data are based largely upon information supplied by mineral producers, processors, and users, and acknowledgment is hereby made of this indispensable cooperation given by industry. Information obtained from individuals by means of confidential surveys has been grouped to provide statistical aggregates. Data on individual firms are presented only if available from published or other nonconfidential sources or when permission of the individuals concerned has been granted.

World production and foreign country trade tables were compiled in the Division of International Activities from many sources including reports from the Foreign Service, U.S. Department of State.

The cooperation of the business press, trade associations, scientific and technical journals, international organizations, and other Federal agencies that supplied information is also acknowledged.

General direction on the preparation and coordination of the chapters in this volume was provided by the Minerals Yearbook staff, which also reviewed the manuscripts to insure consistency among the tables, figures, and text between this volume and other volumes, and between this volume and those of former years.

The Bureau of Mines has been assisted in collecting mine-production data and the supporting information appearing in the Minerals Yearbook by more than 45 cooperating State agencies. These organizations are listed in the acknowledgment section of Volume III.

ALBERT E. SCHRECK,
Editor-In-Chief

Contents

	Page
Foreword, by John F. O'Leary	III
Acknowledgments, by Albert E. Schreck	V
Review of the mineral industries, by Olman Hee and Jeannette I. Baker	1
Technologic trends in the mineral industries (metals and nonmetals except fuels), by John L. Morning	61
Statistical summary, by Kathleen J. D'Amico	85
Injury experience and worktime in the mineral industries, by Forrest T. Moyer	125
Abrasive materials, by J. Robert Wells	139
Aluminum, by John G. Parker	151
Antimony, by L. E. Davis	171
Asbestos, by Paul W. Icke	179
Barite, by W. Gene Diamond	189
Bauxite, by John G. Parker	195
Beryllium, by Henry C. Meeves	207
Bismuth, by Harold J. Schroeder	213
Boron, by J. M. West	217
Bromine, by Keith S. Olson	221
Cadmium, by Donald E. Moulds	225
Calcium and calcium compounds, by Benjamin Petkof	231
Carbon black, by William B. Harper	235
Cement, by John R. Lewis	247
Chromium, by John L. Morning	273
Clays, by J. Robert Wells	283
Coal—Bituminous and lignite, by W. H. Young and J. J. Gallagher	301
Coal—Pennsylvania anthracite, by Walter C. Lorenz	379
Cobalt, by Gilbert L. DeHuff	405
Coke and coal chemicals, by Leonard Westerstrom	411
Columbium and tantalum, by Richard F. Stevens, Jr.	449
Copper, by John W. Cole	463
Diatomite, by J. M. West	495
Feldspar, nepheline syenite, and aplite, by J. Robert Wells	499
Ferroalloys, by John W. Thatcher	505
Fluorspar and cryolite, by J. Robert Wells	515
Gem stones, by Benjamin Petkof	523
Gold, by J. Patrick Ryan	529
Graphite, by Lewis K. Weaver	551
Gypsum, by Paul L. Allsman	559
Helium, by Billy J. Moore	567
Iron ore, by John L. Morning	571
Iron and steel, by John W. Thatcher	593
Iron and steel scrap, by John W. Thatcher	611
Iron oxide pigments, by John W. Thatcher	623
Kyanite and related minerals, by John W. Sweeney	627
Lead, by Donald E. Moulds	631
Lime, by Paul L. Allsman	659
Magnesium, by John W. Cole	669
Magnesium compounds, by John W. Cole	675
Manganese, by Gilbert L. DeHuff	683
Mercury, by J. M. West	693

Page
Mica, by Benjamin Petkof ---- 703
Molybdenum, by John L. Morning ---- 713
Natural gas, by William B. Harper and Leonard L. Fanelli ---- 723
Natural gas liquids, by William B. Harper and Leonard L. Fanelli ---- 751
Nickel, by Gilbert L. DeHuff ---- 769
Nitrogen, by John R. Lewis ---- 781
Peat, by Joseph J. Gallagher ---- 795
Perlite, by William C. Henkes ---- 805
Petroleum and petroleum products, by James G. Kirby and Betty M. Moore ---- 809
Phosphate rock, by Donald E. Eilertsen ---- 921
Platinum-group metals, by J. Patrick Ryan ---- 933
Potash, by Donald E. Eilertsen ---- 943
Pumice, by Carl L. Bieniewski ---- 955
Rare-earth minerals and metals, by John G. Parker ---- 961
Salt, by Benjamin Petkof ---- 969
Sand and gravel, by Paul L. Allsman ---- 979
Silicon, by John W. Thatcher ---- 997
Silver, by J. Patrick Ryan ---- 1003
Slag—iron and steel, by John W. Thatcher ---- 1019
Sodium and sodium compounds, by Benjamin Petkof ---- 1025
Stone, by Paul L. Allsman ---- 1029
Sulfur and pyrites, by Donald E. Eilertsen ---- 1049
Talc, soapstone, and pyrophyllite, by John W. Hartwell ---- 1061
Thorium, by Richard F. Stevens, Jr. ---- 1067
Tin, by John R. Lewis ---- 1073
Titanium, by John G. Parker ---- 1089
Tungsten, by Richard F. Stevens, Jr. ---- 1103
Uranium, by Richard F. Stevens, Jr. ---- 1117
Vanadium, by Gilbert L. DeHuff ---- 1141
Vermiculite, by William N. Hale ---- 1149
Zinc, by Donald E. Moulds ---- 1151
Zirconium and hafnium, by John G. Parker ---- 1179
Minor metals (arsenic, cesium and rubidium, gallium, germanium, indium, radium, rhenium, scandium, selenium, tellurium, thallium), by John W. Cole and Richard F. Stevens, Jr. ---- 1187
Minor nonmetals (greensand, iodine, lithium, meerschaum, quartz crystal, staurolite, strontium, wollastonite), by Benjamin Petkof ---- 1201

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-741/124

Review of the Mineral Industries

By Olman Hee[1] and Jeannette I. Baker[2]

Gains in economic activity were registered in 1968 by the mineral industries as well as by the total economy for the eighth consecutive year. Partly owing to the end of the copper strike, the minerals industry fared better in 1968 than in 1967. Both the minerals industry and the U.S. economy as a whole showed record annual averages in the areas of production, sales, and employment.

The record for 1968 reflects both an overly buoyant economy and resultant benefits to most Americans in the form of large gains in real income and output. These, however, were attained at the cost of serious inflationary pressures. A renewed acceleration in defense spending and an upsurge in consumer spending were special influences that determined the pattern of activity throughout 1968. These developments contributed to the Nation's expansionary path, even in the face of the 10-percent tax surcharge, which was signed into law by the President on June 28. In the minerals economy, the copper strike, which ended in March, and the voluntary agreement by Japanese and European steelmakers to restrain exports of steel, were both important developments.

The value of the Nation's total output of goods and services—gross national product (GNP)—in 1968 rose $71 billion to a new high of $861 billion. When corrected for price changes, the real value of GNP (in 1958 prices) was $707 billion, or 5.0 percent more than in the previous year. As in 1967, a change of pace occurred in economic activity between the first and second halves of the year, but in a reversed order. Growth of real GNP in 1968 was at a yearly rate of 6.5 percent during the first 6 months compared with 4.5 percent during the last 6 months.

The performance of the general economy in 1968 was dominated by excessive demand in several sectors. Personal consumption expenditures increased more than in any recent year and producers stepped up production rates in response to increased sales. Business fixed investment began to move up sharply from its previous high plateau. As a result of these developments, inflationary forces gained a strong foothold in the wage and price structure.

The unusual buoyancy of the economy, reflected by the pressure of demand, pushed up price levels at an unacceptable rate, created a relatively heavy influx of imports, and produced a sharp increase in interest rates. Other highlights of the stimulated economy in 1968 were a strong recovery of productivity growth compared with that for 1967, a 15-year low in the national unemployment rate, and a $10 billion increase in before-tax profits.

The Federal Reserve Board Index of Industrial Production rose 7.3 percent in 1968 from the 1967 level, with total mining, total manufacturing, and utilities each registering moderate increases. Total U.S. employment increased 3.2 percent from 1967 to 1968, and per capita U.S. personal disposable income—corrected for price changes—rose 3.0 percent. The employment category showed a one-third greater increase compared with that for 1967, while the income category continued to increase at about the same rate. Employment in total mining, including fuels, in 1968 showed a modest gain and employment in metal mining showed a considerable increase. Total U.S. unemployment reached a near-record low in 1968, averaging about 3.6 percent of the total labor force.

Total mining output in 1968 was up moderately from the 1967 level, showing the second largest increase in recent years. Metal mining production registered marked gains from the 1967 figure but did not attain the level reached in 1965 and 1966; mining of stone and earth materials was up slightly; and total coal, oil, and gas output was up moderately. Production of iron and steel rose slightly, while nonferrous metals registered moderate to marked gains. Exports of metals (crude and scrap) and crude nonmetallics were up slightly, while manufactured nonmetallic minerals were down slightly. Imports of ferrous ores and nonferrous base metal ores and refined metal displayed a mixed pattern, with representative items such as iron ore showing a slight decline and refined copper exhibiting a moderate increase. Net supply for most light and heavy metals was up in 1968, with generally small increases being registered for major categories.

---

[1] Economist, Division of Mineral Economics.
[2] Commodity research specialist, Division of Mineral Economics.

Developments in the foreign exchange markets nearly triggered a mammoth chain reaction of competitive devaluations by Germany, France, and the United Kingdom. The speculative rush into German marks and reserve losses of the French franc were rooted in national currency problems rather than in basic flaws in the international finance system. The German and French Governments asserted a determination to hold to the present parity and to protect their currency by introducing changes in taxation and by stringent exchange controls.

U.S. Government activities were concerned with efforts to moderate the economic expansion, to continue to curb inflationary pressures, and to strengthen our international trade performance. The Government's policy was to slow the growth of demand to a rate less than the growth of capacity, while consistently maintaining forward motion. Congress at mid-year approved a 10-percent retroactive tax surcharge, withdrawing about $10.5 billion from the private sector income stream. Specific limitations were imposed on Federal budget outlays. Corresponding developments in monetary policy resulted in repeated increases in market interest rates; at yearend rates on short-term Treasury bills and for other market issues were at their peak for recent times. Disposal of material from mineral stockpile inventories decreased moderately; sales were at virtually the same slow pace as in 1967. The Office of Minerals Exploration through its financial assistance program continued to encourage exploration for new domestic sources of essential materials. Government assistance on 18 contracts was largely directed toward exploration for gold, silver, mercury, and copper.

Substantial improvement in U.S. international transactions occurred in 1968. A gain in balance of payments—measured on the liquidity basis—of $160 million was the first to occur since 1957. The change from deficit to surplus was due largely to significant inflows (and reduced outflows) of private and official capital, which more than offset a deterioration in the trade balance in goods and services. Factors contributing to the 1968 surplus include an increase in borrowings by U.S. corporations, directly or through their foreign affiliates; a shift in transactions reported by U.S. banks from a net capital outflow to a net capital inflow; and a rise in foreign purchases of outstanding U.S. securities.

Official U.S. gold reserves continued to decline at about the same rate as in 1967. The reserves were used primarily to meet the demand for gold on the London free market. A continued deficit in silver production induced further withdrawals from silver stocks, with relatively high sales occurring from U.S. Treasury bullion stock.

To insure that adequate mineral resources are developed and made available, Bureau of Mines funding for fiscal 1969 was increased 6 percent. Major thrusts of Bureau of Mines research programs during 1968 were directed toward the development of more effective, efficient, and less costly extraction, processing, and utilization technology. Also, new emphasis was placed on evaluating domestic production capabilities and assessing the outlook for consumption of raw materials in the year ahead. Rapidly increasing domestic demand for mineral raw materials and decreasing domestic production have placed the United States in an escalating deficit position. Within this frame of reference it is the responsibility of the Bureau to see that needed minerals and fuels are provided to consumers at reasonable cost and with no sacrifice in environmental quality. Accordingly, Bureau of Mines research programs were designed to contribute to more effective utilization of our country's natural mineral and fuel resources. Programs in health and safety of miners also received prominent attention, and programs were continued to alleviate the problems in minerals recycling and to improve methods of solid waste disposal.

SOURCES AND USES OF MINERALS

The Federal Reserve Board Index ot Industrial Production for both mining and be quantity of the mineral produced, plus changes in producer stocks, plus (or minus) changes in Government stockpile inventories, plus imports, minus exports. The approach to analysis of demand in this section views demand as a breakdown of consumption into respective use sectors: Commercial sector, industrial sector, transportation sector, and export sector. These approaches should not be construed as being analagous or comparable with analysis of supply-price functions which describe producer behavior or demand-price functions which describe consumer behavior. More realistically, they resemble the balance sheet approach which describes the sources and uses of minerals.

Production.—Domestic production of primary minerals and mineral fuels in 1968 was valued at $25 billion in current dollars, or $1.3 billion more than in 1967 (table 1). In 1957–59 constant dollars, the value of mineral production was $23.6 billion, or 0.8 billion more than in the previous year. In 1968, metals showed the biggest constant dollar increase, 9.6 percent, owing largely to the recovery of copper production after the 1967 copper strike; nonmetals and mineral fuels showed constant dollar increases of 3.2 and 2.6 percent, respectively.

Physical volume of mineral production in the United States in 1968 showed a moderate increase. The Bureau of Mines index of physical volume of production (1957–59=100) showed ferrous metals up slightly and nonferrous metals up substantially, with nonmetals and mineral fuels also sharing in the gain (table 3). Figure 1 shows historical trends for important representative mineral commodities. The production index for iron ore for 1968 was 108.5, down 0.8 index point from the 1967 index; the index for copper was 124.4, up 25 index points (the biggest change); and the index for coal was 114.0, down 6.1 index points. The large change for copper was due to recovery from the precipitous drop during the 1967 strike. (See table 2 in the Statistical Summary chapter, which gives statistics for both production and value of minerals and mineral fuels in 1968).

The Federal Reserve Board Index Of Industrial production for both mining and total U.S. production showed marked relative gains in 1968. The preliminary published data indicated that the index of the total mining component rose 2.6 points to 126.4, while total industrial production increased 6.6 points to 168.7. The primary metals group was up 3.7 index points to 136.2; ferrous metals rose 3.0 points to 129.8; nonferrous metals and products increased 3.9 points to 158.1; the stone and earth minerals group was up 2.6 points to 138.0; and the coal, oil and gas group was up 2.3 points to 125.0.

Among the major nonmetals produced, cement, stone, and sand and gravel combined constituted about 66 percent of total nonmetals production. Cement production, at 405.9 million barrels, was up 5.2 percent; crushed and broken stone output was up 2.1 percent; and sand and gravel production was up 1.2 percent.

The fossil fuels group produced a total heat or caloric value equivalent of 54.8 trillion British thermal units (Btu). Heat value of primary electricity produced at hydropower and nuclear-powered plants, when added to that of mineral fossil fuels, brought the total to 57.3 trillion Btu. This was a record level, and 3.4 percent higher than in 1967.

Primary fossil fuels continued to supply the bulk of the Nation's energy supplies. Natural gas and component liquids remained the top energy source, with a marketed production of 19,322 billion cubic feet, or 6.3 percent higher than in 1967. Crude petroleum furnished the second most important source of energy, with a marketed production of 3,329 million barrels, or 3.5 percent more than in 1967. Higher demand for crude petroleum in 1968 was met by increased domestic production and increased imports. Production of bituminous coal and lignite declined 7.6 million short tons to a total of 545 million short tons, the first time in 7 years that this fuel did not show an uptrend. Anthracite continued to show a slight decline, with a production of 11.5 million short tons. The smallest source of energy came from primary electricity generated at hydropower and nuclear-powered plants, with 2,352 trillion and 130 trillion Btu

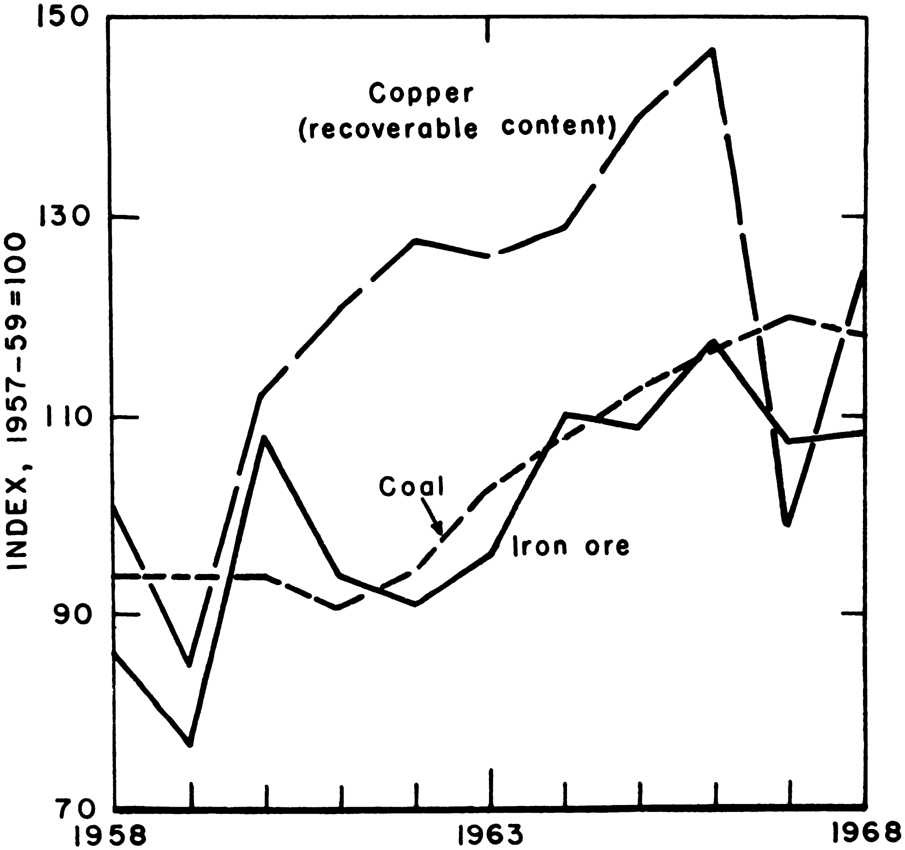

Figure 1.—Indexes of physical volume of mineral production for selected items in the United States.

produced in 1968 compared with 2,344 trillion and 81 trillion Btu in 1967.

The net supply of most minerals increased. Several important ferrous metals, including iron ore, steel ingot, and tungsten, showed a slight to moderate increase in net supply, while most nonferrous metals showed only slight gains. Steel ingot showed a sizable increase in both production and imports, while iron ore and tungsten showed their biggest gain in production only. For the nonferrous metals, copper, lead, and platinum reflected the biggest gains in domestic production while both copper and aluminum showed sizable gains in imports. Exports of the more important ferrous metals declined, while with the exception of aluminum, crude and semicrude, exports of important nonferrous-metals increased. Exports of refined copper recovered in 1968 to match the 1966 level of exports.

Changes in the relative shares of domestic and foreign sources of supply occurred in a few selected minerals. More reliance was placed on foreign sources in 1968 for iron ore and concentrate, ores and concentrates of nonferrous metals, refined copper, manufactured aluminum, nickel and nickel alloys, and zinc and zinc alloys. Fewer supplies from foreign sources were registered for pig iron, and lead and lead alloys.

Stocks and Government Stockpile.—Producers' stocks of crude minerals in both metals and nonmetals were up substantially in 1968. The Bureau of Mines index of stock of total crude minerals stood at 127 (1957–59=100), with metals contributing most to the increase. The index for iron ore (1957–59=100) reached 227 in 1968, a record level and 43 index points higher than in 1967, while the nonferrous metals index stood at 178, or 1 index point higher than in the previous year. Producers' stocks of nonmetals rose to 93 (1957–59=100) or 15 index points higher than in 1967. A marked increase in Frasch sulfur stocks contributed materially to the higher nonmetal stocks on hand.

Seasonally adjusted book values of inventories in the mineral processing industries were up moderately for petroleum and coal products, and up sharply for stone, clay, and glass products at yearend 1968. By contrast, the inventory position for blast furnaces and steel mills was moderately down. To more than offset the decline in this component of primary metals, other primary metal inventories were up moderately. Overall book value of inventories for the mineral processing industries showed a greater increase than for the past several years.

Like producers' stocks, the national stockpile of strategic materials helps to bolster the Nation's supply of minerals. Important ferrous metals in the stockpile in terms of market value were tungsten, metallurgical chromite, and metallurgical manganese, in that order. Important nonferrous metals in the stockpile in terms of market value were aluminum (bauxite), zinc, lead, and tin. Among the ferrous metals, molybdenum maintained about the same quantity level as in 1967; among the nonferrous metals, bauxite maintained its previous quantity level.

Exports.—Since exports reduce the Nation's domestic supply of minerals, interest centers on particular groups of minerals exported. In 1968, exports of chemicals and manufactured nonmetallic minerals exceeded imports slightly to moderately. Exports of inorganic chemicals showed a marked increase. In the nonmetallic minerals group, clay and refractory construction materials and nonmetallic mineral manufactures showed the largest gains. The value of total exports of minerals and mineral products in 1968 was 6 percent greater than in 1967.

Imports.—Imports add to the Nation's domestic supply of minerals. The quantity of minerals and mineral products imported in 1968 for most items in the crude and scrap metals category was moderately higher, and in the manufactured metals category substantially higher, than in 1967. Significant increases in imports among the ferrous metals included pig iron, steel ingot, and nickel. Among the nonferrous metals, copper and copper alloys, aluminum and aluminum alloys, zinc and zinc alloys, and tin and tin alloys showed moderate to marked increases. The value of total imports of minerals and mineral products in 1968 was 22 percent greater than in 1967.

Consumption.—Among the major metals, changes in consumption of both ferrous and nonferrous categories were mainly upward (table 7). Iron ore and raw steel consumption were up 4.3 million long tons and 4.2 million short tons, respectively. Among the nonferrous group, copper consumption was down 2.9 percent, while aluminum was up 16 percent. Uranium consumption (U_3O_8) went up 3.2 thousand short tons during the year to a total of 12.3 thousand short tons.

Among the major nonmetals, consumption of cement rose to 403 million barrels, or 25 million barrels more than in 1967. Sand and gravel consumption rose to 917 million short tons from 907 million short tons used in 1967. Crushed stone for all uses totaled 816 million short tons, or 32 million short tons more than in 1967. Among the important nonmetal commodities which registered declines in consumption were phosphate rock, down 9 percent; and sulfur, down 2 percent. Unfavorable weather in the spring of 1968 caused many farmers to plant emergency crops that require less fertilizer or to delay plantings of regular crops and to apply less fertilizer to the delayed plantings.

Total energy consumption in the United States reached a new high of 62.3 quadrillion Btu, an increase of 5.8 percent over 1967 consumption. Petroleum and natural gas liquids constituted 44 percent of total energy sources consumed; natural gas, 31 percent; bituminous coal, 21 percent; and hydropower and nuclear power, 4 percent.

Petroleum consumption, including natural gas liquids, rose to 4,900 million barrels, an increase of 7 percent. This was the largest increase in petroleum consumption in the last several years.

Natural gas consumption rose to 18,957 billion cubic feet, an increase of 7.2 percent. Increased importance of liquefied natural gas in the last several years has given an added boost to total gas energy consumption.

Bituminous coal consumption in the United States reached 499 million short tons, an increase of 4.0 percent. The electric utility industry continued to be the largest consumer, utilizing 294 million tons of coal, or about 8.1 percent more than in 1967. Industrial uses accounted for 188 million tons, of which 90 million tons were used to make coke, 15 million tons were used for retail delivery, 9 million tons were channeled to cement mills, and 6 million tons were used by steel and rolling mills. Development by electric utilities of mine-mouth generating stations, which use high-voltage transmission lines to transport power, has increased the use of coal. A Bureau of Mines demand study of coal for electric generation yielded a price elasticity of demand of —0.72 for coal in this use. This indicates an inelastic demand for coal by generation plants and suggests that decisions with respect to changes in the level of coal consumption by generation plants are only moderately affected by changes in the price of coal.

Hydropower and nuclear power continued to increase in importance in furnishing energy in 1968. Hydropower generation output was 222.2 billion kilowatt-hours, or 0.4 percent more than in 1967. Nuclear power generation output jumped to 12.3 billion kilowatt-hours from 7.6 billion kilowatt-hours in 1967, an unprecedented increase of 61 percent.

The industrial sector continued to be the major energy market in 1968, using 31 percent of total energy consumption or 2.8 percent more than in 1967. Coal and natural gas continued to increase as sources of energy in this sector, while petroleum showed a slight decline.

The transportation sector accounted for 24 percent of total energy consumption or 8 percent more than in 1967. The largest share, by far, of energy used in this sector was furnished by petroleum.

The household and commercial sector accounted for 22 percent of total energy resources consumed in 1968 (table 9). With the exception of coal, energy resource inputs into this section continued to increase; the input for natural gas increased 4.6 percent, while that for petroleum increased 0.4 percent. For the first time natural gas was the principal source of energy in the household and commercial sector.

The electric utility sector utilized about 22 percent of the total energy resource input, slightly more than in 1967. Bituminous and lignite coal, the major fuel used in electric generation, increased from 6.6 to 7.1 quadrillion Btu. Natural gas and petroleum, which together furnished 31 percent of total energy inputs in this sector in 1968, continued to increase percentagewise a little faster than coal. Total energy input in this sector increased 9 percent in 1968.

Total gross energy inputs, over all sectors, increased 6 percent in 1968. Fossil fuels comprised 95 percent of total energy input, and hydropower and nuclear power made up the remainder. Of the fossil fuels, petroleum furnished the highest total energy input, 43 percent, followed by natural gas and coal.

EMPLOYMENT AND PRODUCTIVITY

Employment.—Employment in the mineral industries generally rose, with moderate gains in total mining offsetting a slight decline in total minerals manufacturing (table 25). Both metal mining and mineral fuels contributed to the general rise in total mining employment. The gain in employment in metal mining resulted largely from recovery from the low level set in 1967 due to the copper strike.

Percentage changes in employment in 1968 compared with 1967 by groupings follow:

	Percent
All industries	+3.2
Mining (including fuels)	+2.0
Metal mining	+6.4
Nonmetal mining and quarrying	+.7
Coal mining	−2.0
Crude petroleum and natural gas	−1.1
Oil and gasfield services	+9.1
Minerals manufacturing	(1)
Nonfuel minerals [2]	+.3
Fuels	−1.4

---

[1] **Less than 0.1 percent.**
[2] **Based on selected items given in table 24.**

Employment in selected minerals manufacturing industries declined slightly. Fertilizers and hydraulic cement had slightly lower employment for the second consecutive year; blast furnaces, steelworks and rolling mills, and nonferrous smelting and refining were up slightly. Employment was down in petroleum refining and in other petroleum and coal products. Total U.S. employment showed a slightly greater gain in 1968 compared with 1967.

Hours and Earnings.—Changes in average hours worked in metal mining were mixed; fewer hours were worked per week in iron ore mining, but there was a lengthened workweek in copper ores. Weekly hours per worker in copper mining, at 47.2, was a record high for the last decade. The longer workweek was due principally to demand built up during the copper strike. Weekly and hourly earnings in metal mining increased 8.7 and 5.2 percent, respectively. For the mineral fuels group, average hours declined slightly, with coal mining contributing largely to the decrease. Weekly earnings increased 5.4 percent in crude petroleum and natural gas plants, but only 0.4 percent in coal mining.

Average hours worked in petroleum refining and related products declined 0.5 percent. For all other nonfuel minerals and fuels manufacturing industries, except fertilizers, the workweek increased. Increases in weekly earnings in various categories of nonfuel minerals and fuel manufacturing ranged from 4 to 8 percent, slightly more than the increases in 1967. Increases in hourly earnings in this group in 1968 ranged from 5 to 7 percent. For total manufacturing, all industries, the average increase in weekly earnings was 7.6 percent, or substantially greater than that in 1967.

Labor Turnover Rates.—Accession rates (hires and rehires) for metal mining dropped slightly in 1968, while for all manufacturing they rose slightly. Accession rates for iron ore returned to 1965–66 levels after a surge upward in 1967, while for copper ore little change was registered from the earlier levels. Separation rates were lower for total metal mining, and for copper mining they were substantially lower. Accession rates generally increased for the mineral manufacturing industries. Hydraulic cement was the only industry reporting fewer separations than in 1967. In mineral fuels manufacturing, accession rates in both petroleum refining and coal mining increased slightly; separation rates increased in petroleum refining but declined in coal mining. Layoff rates remained stable in coal mining, while for petroleum refining they declined.

Wages and Salaries.—Wages and salaries in the mineral industries (including fuels) continued to rise. For mining, wages and salaries increased 4.8 percent, compared with 8.7 and 9.8 percent, respectively, for manufacturing and for all industries, total. Wages and salaries improved in the mining industry relative to other industries. Average earnings per full-time mining-industry employee at $7,958 annually, exceeded the $7,345 average received by manufacturing employees and the $6,654 all-industry average. Earnings per employee in mining in 1968 increased 5.3 percent, while in manufacturing and all industries they increased 6.8 and 6.7 percent, respectively.

Productivity.—The 1967 productivity indexes (most recent data available) reflect a mixed pattern of gains and losses for the production worker man-hour category in the important mining sectors. An increase in output per production worker man-hour of 4 index points (1957–59=100) was registered for crude iron ore in 1967, while for bituminous coal and lignite there was no change from the 1966 index. Output per production worker man-hour for copper, both crude ore and recoverable metal, was down slightly in 1967. For usable iron ore, the productivity index declined 6.6 points. Where labor productivity declined, it was due largely to output falling faster than number of production workers.

PRICES AND COSTS

Index of Average Unit Mine Value.—During 1968 the index of average unit value for all minerals increased about 1 percent. Largely because of the relative stability of fossil fuel prices, the overall index has changed relatively little since 1958. Increases in the component items of the index occurred in such ferrous metals as iron ore and tungsten; in nonferrous metals, especially copper; and in the monetary metals, silver and gold. Among the nonmetals, prices in the construction category showed little change, while prices of several items in the chemical category, such as phosphate rock and potash, were down slightly to moderately. Average mine value of mineral fuels trended upward in 1968, with crude petroleum and natural gas registering slight increases.

Index of Implicit Unit Value.—The index of implicit unit value, which measures change in value index-quantity index relationships, showed a modest increase of 1.9 index points for all minerals (1957–59=100). Ferrous metals showed a slight increase, while nonferrous metals, both base and monetary categories, showed marked increases. Monetary metals, with silver leading all others, increased 30.7 index points. Base metals trended upward at a lesser rate, rising by 7.9 index points. The relatively rapid rise in prices of base and monetary metals in 1967 and 1968 brought about record levels for these categories for recent times. Within the nonmetallic group, the index of prices of raw materials used in the construction and chemicals industries rose relatively little, while prices of other nonmetals, such as clays (fuller's earth, and kaolin), rose as much as 15 index points. The sharp increase in the unit value of monetary metals in 1968 was mainly due to speculation stemming from uncertainties in the silver market. The U.S. Treasury attempted to stabilize the silver market by releasing 2 million ounces per week for an extended period. The implicit unit value for gold rose about 10 index points over that of 1967. This was principally due to establishment by the Federal Government of a two-tier price structure for gold, allowing the price of gold in private transactions to fluctuate based on supply and demand conditions for gold in the open market.

Prices.—Prices for most major metals, nonmetals, and mineral fuels rose moderately in 1968 (table 32). Iron and steel and aluminum ingot showed gains of 1.8 and 2.0 percent, respectively. Offsetting these gains were moderate to marked declines in the prices of lead, zinc, and iron and steel scrap. Among the nonmetallic minerals, prices of construction materials were universally up, while prices of many chemical raw materials showed moderate declines. Mine prices for phosphate rock were unchanged, while prices for potash were down 11.6 index points. Prices to farmers for phosphate fertilizer (46 percent P_2O_5) were down 7 percent, and prices for potash (standard, muriate, 60 percent K_2O minimum) were down 6.5 percent. Relatively heavy increases in fertilizer supplies during the year, together with a less than proportionate increase in domestic demand, contributed materially to the price decreases.

Average cost of coal at steam-electrical powerplants rose by 0.5 cent to 25.2 cents per million Btu in 1967 (the latest year for which data are available). Cost of residual fuel oil decreased by 0.2 cent to 32.2 cents while natural gas decreased by 0.3 cent to 24.7 cents per million Btu. For principal user areas, natural gas became the cheapest fossil fuel for power generation in the United States. In one of the three regions in the East, natural gas prices per Btu declined in 1967 compared with 1966 levels, while in all regions of the East, the price of coal registered increases.

The average cost of electrical energy remained at 1.6 cents per kilowatt-hour in 1967. Within the regional breakdown, small declines in cost were shown for the Middle Atlantic, East North-Central and West South-Central regions, which had shown no change in cost in 1966. The East South-Central region continued to have the lowest average cost for power in 1967, 0.9 cent per kilowatt-hour. Cost of electrical energy remained lowest in the commercial and industrial markets—1.3 cents per kilowatt-hour—and highest in the residential market—2.2 cents per kilowatt-hour.

Index of Principal Metal Mining Expenses.—Higher index values for principal metal mining expenses were reported in 1968, owing largely to significant increases in labor costs. Prices of supplies, fuels, and electrical energy showed only nominal change. The indexes of major input expenses for bituminous coal, crude petroleum, and natural gas showed no appreciable change.

Costs.—The indexes of relative labor costs and productivity in the mineral and mineral fuels industries in 1968 generally continued to rise over those of 1967 (table 38). The index of labor costs per unit of output for recoverable iron ore in 1968 was about the same as in 1967; for copper, the index was up markedly. The index of value of product per man-period was up moderately for recoverable iron ore and up substantially for copper. The index of labor costs per dollar sales remained unchanged for recoverable iron ore and was slightly down for copper. It is noteworthy that the index of labor costs per dollar sales for copper declined in contrast with other labor cost measures for that metal. Except for portable air compressors, prices of principal mining construction and material handling machinery were up in every category in 1968. Prices of construction machinery and mining machinery increased 6.4 and 3.7 percent, respectively. In the specialized categories tractors, other than farms, showed the largest price increase, while power cranes, draglines, shovels, etc. showed the smallest increase.

INCOME AND INVESTMENT

National Income Generated.—Income generated by mining was $6.5 billion, the highest of record and 5.8 percent higher than in 1967 (table 41). Income from metal mining was 11.7 percent higher than in 1967, but lower than the 1963–67 average. An increase of 6.1 percent in income in the crude petroleum and gas industries helped considerably to boost income for total mining. Similarly, income in manufacturing rose to a new record in 1968, or 10.1 percent higher than in 1967. A 9.2-percent increase in income was registered in all industries, U.S. total.

Profits and Dividends.—Annual average profit rates in 1968 on shareholders' equity in selected mineral manufacturing corporations were slightly lower for primary metals, while for all manufacturing they were slightly higher. Profit rates for petroleum refining and related industries, which declined 0.3 percent in 1968 were the lowest since 1966. In contrast, profit rates in 1968 for stone, clay, and glass products and chemical and allied products increased 1.0 and 0.2 percent, respectively. Dividends in mineral manufacturing generally showed moderately large increases. Primary metals, chemicals and allied products, and petroleum refining and related industries registered increases in dividends of 6 to 8 percent, while the stone, clay, and glass products group showed a slight decline. Except for the stone, clay, and glass products group, total dividends fared better than profit rates in all categories in 1968.

There were 57 industrial and commercial failures in mining, including fuels, 14 fewer than in 1967; however, liabilities reported by these firms were almost 20 percent higher in 1968. Manufacturing firms, which comprise a much larger category of firms than mining, showed 305 failures, or 17 percent fewer than in 1967; in addition, these firms reported 13 percent less liabilities than in 1967.

New Plant and Equipment.—Expenditures for new plant and equipment by mining firms totaled $1.42 billion, unchanged from that in 1967. In the manufacturing category, expenditures for chemical and allied products and stone, clay, and glass products declined 6.6 and 2.7 percent, respectively. New plant and equipment expenditures for primary iron and steel rose $50 million to $2.36 billion. Expenditures in the all-manufacturing category decreased 0.9 percent to $26.44 billion.

Plant and equipment expenditures of foreign affiliates of U.S. companies in mining and smelting rose $199 million to $1.1 billion. This 22-percent increase in outlays compared favorably with the 10-percent increase reported for manufacturing. Except for the category "mining and smelting in all other areas," each area reporting showed increased outlays for mining and smelting. All countries reporting showed increases in petroleum outlays. Except for Canada, all countries reporting showed increases in outlays for manufacturing.

Issues of Mining Securities.—Estimated gross proceeds of new corporate securities offered for the extractive industries in 1968 were $594 million, or 1.0 percent more than the $588 million offered in 1967. Slightly more than one-third of the proceeds in extractive industry offerings during the year came from bonds, about two-thirds was in common stock issues, and none was reported from preferred stock.

Sources and Use of Funds.—In 1965 (the latest year for which data are available) funds from all sources for direct foreign investment by U.S. mining and smelting industries increased $323 million to $1.4 billion. Canada and Latin America led all other countries in generating funds. The affiliates relied principally on net income originating within the industries. In the more undeveloped areas, funds borrowed abroad and from the United States dominated the funding pattern.

Uses of funds for direct foreign investments by U.S. mining and smelting industries for property, plant, and equipment in 1965 (latest data available) increased $219 million to $682 million. Funds expended for property, plant, and equipment constituted about 50 percent of the total; income paid out accounted for about 30 percent; inventories utilized 7 percent; and the remainder was distributed to receivables and other assets.

Foreign Investment.—Direct private investment of U.S. foreign affiliates in foreign petroleum industries in 1967 was highest in Europe, Canada, and the Latin American Republics. Total book value at yearend for petroleum industries, all countries, was $17.4 billion, compared with $16.2 billion at the beginning of the year, or a gain of 7 percent. Book value for all industries rose from $54.7 to $59.3 billion, or 8 percent.

Direct U.S. private investment in foreign mining and smelting industries in 1967 was valued at $4.8 billion, or 17 percent above that in 1966, the highest increase in recent years. Canada and the Latin American countries accounted for almost three-quarters of the investment in mining and smelting, and slightly over two-thirds of the income generated by these industries. In 1967, earnings of affiliates in mining rose by $83 million, reaching $743 million. Of this total, $596 million was returned to the United States as income, compared with $524 million in 1966.

TRANSPORTATION

In 1967 (the latest year for which data are available) the overall shares of metallic ores and nonmetallic minerals (except fuels) transported by rail and water remained unchanged from 1966. Individual metals and nonmetallic minerals which showed higher rail transport as compared with water in 1967 follow: Iron ore and concentrates, bauxite, other nonferrous ores, phosphate rock, processed fertilizer, building cement, and clay, ceramic, and refractory materials. Items, by groups, that showed higher water than rail transport were gypsum and plaster rock, liquid sulfur, and limestone flux and calcareous stone. Mineral commodity tonnages (except fuels) transported by rail were down 6 percent in 1967 compared with those in 1966, while those transported by water were down 4 percent.

In 1967, the greater quantity of mineral fuels and related products continued to be moved by water rather than by rail or truck. The quantities moved in waterborne commerce increased 3.9 percent in 1967. For the first time, the tonnage of crude petroleum moved by water exceeded that of gasoline (including jet fuel). Crude petroleum was by far the greatest contributor to the annual increase in mineral-fuels tonnage moving by water transport. Mineral-fuels tonnage moving by rail increased slightly less than 1 percent in 1967. Among the important items, bituminous coal contributed most to the absolute increase; however, percentagewise, liquefied petroleum gas led all others. Increased shipments of coal by rail in recent years stem principally from lower freight rates.

Gas pipeline mileage totaled 828,000 miles in 1967 (latest year for which data are available), or 4 percent more than in 1966. Natural gas lines continued to comprise about 99 percent of the total, with the remaining 1 percent divided among manufactured, mixed, and liquefied petroleum gas.

Total petroleum pipeline mileage, recorded at the beginning of 1968 at 210 thousand miles, was down slightly less than 1 percent, the first reduction in the last four decades. Total pipeline fill at the beginning of 1968, at 104.6 million barrels, was 3.9 percent greater than that reported for 1965. This was a markedly lower increase than that shown for the 1962–65 period. Of the total petroleum pipeline mileage reported in 1968, 35 percent was in crude gathering systems in field operations, 34 percent in larger size crude trunklines, and 31 percent in petroleum product pipelines that extend from refineries to distribution terminals.

RESEARCH ACTIVITIES

Data on national expenditures for research and development activities in selected industries in 1967 (latest year for which data are available) showed that chemicals and allied products accounted for 9.5 percent of total funds expended, or slightly more than revised data show for 1966 (table 56). Petroleum refining and extraction accounted for 2.9 percent of the total, slightly more than in 1966. Federal funds in 1968 made up slightly under 15 percent of the total spent for chemicals and allied products research, and slightly under 10 percent of that expended on petroleum refining and extraction research. Only about 3.0 percent of Federal funds available for industrial research was spent on research related to the chemical industry and the petroleum industry. Of this amount, 2.5 percent was expended for chemicals and allied products research, and 0.5 percent on petroleum refining and extraction.

Bureau of Mines.—During 1968, the Bureau of Mines continued to work on research problems under established programs for minerals and mineral fuels research and resource development. Emphasis again was placed on supply-demand-price relationships. From relationships derived, supply and demand forecasts into the next two decades were made, with a view to making research efforts more meaningful in those areas where supply and demand are most critical. Emphasis also was placed on determination of input-output relationships of the U.S. mining industries, using 1963 data. Energy supply and demand balances, 1960 and 1965, for coal, utility electricity, dry natural gas, and petroleum and natural gas liquids were completed in 1968. These separate commodity balances and flows are input requirements for the construction of integrated energy balances at the State and regional levels.

Obligations of funds by the Bureau of Mines for mining and mineral research and development totaled $35.8 million in fiscal year 1969. Of this amount, 74 percent was allocated to applied research, 12 percent to basic research, and 14 percent to development. Total research funds of $30.8 million obligated by the Bureau for fiscal year 1969 were divided as follows: Engineering science, $20.1 million; physical sciences, $8.4 million; mathematical sciences, $0.7 million; and environmental sciences, $1.6 million.

Research on technological and economic problems was designed to continually advance the process of extracting raw materials at reasonable cost without environmental degradation. Highlights of accomplishments of Bureau research programs, including work in progress, follow.

Mining Research.—As an aid in reducing the incidence of waste disposal structure failures and resulting pollution, a comprehensive report was completed on the various factors affecting the stability of mill tailings dams. In ground control studies, a multiple-anchored borehole extensometer was developed for detecting and measuring subsurface rock movements caused by underground mining. A related study was initiated to determine interrelationships between surface subsidence, mineral extraction ratio, elapsed time between mining activity and surface subsidence, and the character and nature of overburden materials. A technique was devised for measuring stress changes in viscoelastic materials by means of hydraulic pressure cells and then relating these data to size and distribution of supporting mine pillars, depth of overburden, and type of mineral deposit. Laboratory studies on strength of mine pillars determined that the compressive strength of fractured pillars can be increased significantly by angular placement of rock bolts.

As an aid toward prevention of damage to surface structures, field studies were completed which relate air and ground vibrations, caused by blasting operations, to the size of the explosive charge, the distance between blasting site and surface structures, and the physical characteristics of the blasted materials. Studies were initiated on the potential of thermal fragmentation by laser radiation and by radiofrequency inductive heating.

In marine minerals research, emphasis was centered on the development of equipment and techniques to accurately sample and characterize sea-floor deposits. Following up on the attention given to gold-bearing placer deposits, blanket-type phosphorite deposits were added in 1968 in research investigations conducted on Coronado Bank, off the coast of southern California.

Metallurgy Research.—A new method for consolidating reactive metals was developed, wherein charges of titanium sponge, scrap, or mixtures thereof are melted under a layer of molten slag in a water-cooled crucible, and the solid metal is then withdrawn as a continuous rod through the bottom of the crucible.

Because of the continuing interest in vanadium—especially its potential as a structural material—the Bureau's electrorefining process for preparing 99.99-percent-pure vanadium—the highest ever achieved in a process adaptable to commercial production—has been improved and scaled up.

A process was developed for electrolytically oxidizing organic matter in the carbonaceous gold ores of Nevada, prior to cyanide treatment. Pilot-plant trials are under way by a prominent gold mining company operating in that State. Successful conclusion of the tests may lead to large additions to both domestic and world gold reserves. Another process has been worked out for the continuous recovery of gold from the heap leaching of oxidized ores in the sedimentary beds of northeastern Nevada. More than 90 percent of the gold content of these ores can be extracted.

An important breakthrough was made in the formulation of a new soldering procedure, whereby replacements of conventional lead-silver-tin solders can be made by materials which melt at temperatures about 100° F higher than are now possible and which maintain good strength at elevated temperatures. The method has considerable promise in the automotive industry for the production of smaller and more efficient copper alloy radiators.

Land and Air Pollution.—During 1968, the Metallurgy Research Solid Waste Program centered on three main areas of research: (1) Recovery and utilization of the metal and mineral content of municipal incinerator residues, (2) stabilization (utilization) of mine and mill waste piles, and (3) recovery and utilization of ferrous and nonferrous values contained in scrap automobiles. A modest grant program also was continued to supplement inhouse research on solid waste problems.

Major accomplishments during the year included completion of a 1,000-pound-per-hour continuous processing plant for recovering the ferrous, nonferrous, glass, and mineral values contained in municipal incinerator residues, construction of a pollution-free scrap automobile incinerator, and stabilization of two large uranium mill tailings piles by vegetative and chemical methods.

The grant program provided funds for development of methods for utilization of mine and mill wastes. A crystallized glass was made from copper tailings, a promising refractory was produced from asbestos tailing waste, high-quality ferrites were fabricated from mill scale, and commercially competitive building bricks were made from copper and gold mill tailings.

In cooperation with the American Petroleum Institute, Bureau researchers completed a fuel study in 1968 which found two options for lowering automotive emissions. One option is reduction in front-end volatility, and the other is a change in fuel composition while maintaining volatility. Either will reduce emissions when both fuel systems and exhaust contributions are considered.

The Bureau has nearly completed a cooperative study with the National Air Pollution Control Administration on diesel exhaust pollution. Also, preliminary work was initiated on measuring aircraft emissions. It was found that equipment of essentially the same design can be used for testing both automotive and aircraft emissions.

Coal Research.—Investigative research progressed in 1968 on conversion of coal to electricity. Field tests were made at lignite-burning powerplants to study the problems associated with lignite combustion. In the laboratory, electron microprobe analysis of boiler deposits showed that interaction between sodium compounds and alumina silicates played a significant role in boiler fouling. A mathematical model was devised for combustion of coal in a magnetohydrodynamic system. It showed that magnet and generator costs can be considerably reduced by operating the generator below stoichiometric air-fuel ratios and by injecting additional air downstream from the slag separator.

In a study of conventional combustion techniques, an experimental 500-pound-per-hour pulverized-coal-fired furnace successfully underwent shakedown tests and was readied for tests using pulverized char as fuel. The development of an effective method for burning char is essential to the overall development of economical processes for converting coal to synthetic gaseous and liquid fuels, since char constitutes a significant portion of the product in the several conversion processes being investigated. In a pilot study of the combustion process, coals and chars were devolatilized under conditions simulating heating rates in a boiler. Heating rates of about 10,000° C per second were provided by metallic ribbons of filaments injected with short pulses of electrical energy.

Further studies were conducted to evaluate the use of solid wastes from the combustion and mining of coal. Surface-mine spoil field areas, reclaimed with fly ash to counteract soil acidity, produced hay yields comparable to yields from other conventionally treated acreages in the same area.

In non-energy-use research, field tests on the use of pulverized leonardite to stimulate plant growth showed that the yield of potatoes was increased 28 percent and that of soybeans as much as 280 percent over control plots. Minerals in a large variety of coals and coal-related materials were identified by extended infrared spectrometry. A new freeze-crush technique, whereby coal samples are pulverized while submerged in liquid nitrogen, was developed for studying gases held in the coal matrix. Also, carbonization research produced cokes of improved strength, and research was started to determine the feasibility of making metallurgical-grade coke from coals of marginal quality.

Research conducted on methods for converting coal into liquid fuels showed that, in the reductive alkylation of coal, the solubility in benzene of the alkylated product increases as the carbon chain in the alkyl radical increases. Butylated coal was 96 percent soluble in benzene. Findings indicated that in the hydrogenation of coal with carbon monoxide and steam the extent of solubilization of coal is dependent on the oxygen content and type of linkage.

Progress was made on development of a fluidized steam-oxygen gasification process operating at 40 atmospheres' pressure. In this process, 60 percent of the potential methane of the coal is made during the gasification step, which significantly reduces the cost of producing synthetic pipeline gas. Using this gasification process and Bureau-developed purification and synthesis steps, the cost of pipeline gas would be very close to that for the natural product in some areas of the country.

Petroleum Research.—A technique for locating fracture trends by means of aerial photographs was developed in petroleum and natural gas research. It was used, along with subsurface studies, to determine possible effects of the natural fracture system on gas storage reservoir performance. Also, investigation was made to see if wells used during withdrawal could be modified to increase the efficiency of the system.

Long-term flow tests were initiated on gas from the nuclear-explosive-created chimney in the Gasbuggy experiment. The success of this first joint Government-industry experiment in the peaceful use of nuclear explosives, designed to release natural gas trapped in low-permeable rock, led to completion of preparations for a second experiment. Project Rulison, to be conducted in Colorado—also a Government-industry sponsored experiment—will be the first test of the nuclear fracturing concept in what could be a commercially productive gasfield.

To further the science of secondary recovery of petroleum, work was completed on a combination method of predicting waterflood performance for five-spot patterns in stratified reservoirs. This computer method is attracting widespread interest in the petroleum production industry. Research on characterizing asphalt and the heavy ends of petroleum was directed to new methods of analysing these substances to yield knowledge required for better processing and utilization of these materials.

Oil Shale Research.—In a pioneering experiment conducted in Sweetwater County, Wyo., with respect to the feasibility of retorting oil shale in situ, the Bureau successfully recovered oil from oil shale without mining it. The shale was fractured by applying high-voltage electricity between wells drilled into the shale, pumping water down the wells under high pressure, and enlarging the resulting fractures by detonating a liquid explosive in them. The 20-foot-thick shale layer, beginning 68 feet below the surface, was ignited by a propane burner in the central well, and combustion was sustained by pumping air underground after shutting off the propane. Oil in the form of mist began to appear in peripheral wells only a few hours after propane shut-off, and reported production was as high as 4.5 barrels per day. The success of this test raises hopes for Project Bronco, a proposed Government-industry experiment involving in situ retorting of shale fractured deep underground by a nuclear detonation.

In other research aimed at retorting nuclear-fractured shale, a 150-ton-per-day retort was being constructed in Wyoming in which tests can be conducted on large random-sized pieces of shale, simulating conditions expected in a nuclear chimney.

Research on the origin and nature of oil shale yielded information which can be used to predict properties and organic content of oil shales over wide areas.

Economic Studies.—Emphasis was placed by the Bureau on supply and demand analysis of minerals and mineral fuels. Results of work completed in 1968 on a study of current and future demand for phosphate rock, potash, and nitrogen have just been published, and demand studies on iron and steel, aluminum, and copper were progressing.[3] These studies seek to develop the general methodology for statistical analysis of supply and demand for important minerals, and to present results and implications of in-depth research on supply and demand for the principal minerals and mineral fuels. As a result, mining and metallurgical research projects can be directed to the respective areas where current and future demand and supply imbalances are most critical.

In addition to studies on supply and demand, work progressed on studies of energy sources and uses, environmental health, and local and regional economic impact of adverse effects in the mining sector. Results of work completed in 1968 on studies of sources and uses and interregional energy flows for coal, natural gas, utility electricity, and petroleum and natural gas liquids were published.[4]

Studies in the area of environmental health were made with particular emphasis on mineral-based products used in combatting noise, economic aspects of strip mine regulation, and the economic impact on localized producing areas of a shift in the demand from high- to low-sulfur coal.

Four contract studies on non-fuels mineral policy were in varying stages of completion.

Health and Safety.—The Health and Safety Program in 1968 emphasized mine inspection, health and safety education and training, research and statistical analysis, and coalbed-fire control. The projects have as their principal objective the conservation of human and natural resources in the mineral extractive industries. The Department of the Interior drafted proposed legislation in mid-1968 to replace and amplify health and safety measures in the Federal Coal Mine Safety Act. Bills were introduced into both Houses of the 90th Congress in September 1968; however, they lapsed with the adjournment of that Congress in mid-October. Only a little more than a month later, a series of underground mine explosions killed 78 coal miners near Mannington, W. Va. The disaster stimulated a significant escalation of public interest in coal mine safety and health, as well as forums conducted to air the urgency of safety measures. The Interior Department drafted still more comprehensive legislation, based on evidence from joint industry and Government conferences. At yearend, more than 1,800 individual standards had been prepared for publication in the Federal Register as a Notice of Proposed Rule Making.

Explosives and Explosions Research.—Recent investigation disclosed that adding certain inhibitors to relatively nonincendive formulations of sensitized ammonium nitrate-water slurry explosives increases their stability in maintaining basic characteristics for several months. These materials can be packaged and used in gassy, underground noncoal mines. In cooperation with the U.S. Coast Guard, studies were made of hazards associated with the accidental spillage of large quantities of liquefied natural gas, on or under the water surface, at the Bureau's new underwater explosive testing facility. In several instances, minor explosions occurred when cryogenic liquid entered the water. No explanation is presently available for such phenomena.

---

[3] Hee, Olman. A Statistical Analysis of U.S. Demand for Phosphate Rock, Potash, and Nitrogen. BuMines Inf. Circ. 8418, 1969, 55 pp.

[4] Broderick, Grace N. Supply and Demand for Energy in the United States by States and Regions, 1960 and 1965 (In Four Parts) 1. Coal. Inf. Circ. 8401, 1969, 21 pp.

Crump, Lulie H. Supply and Demand for Energy in the United States by States and Regions, 1960 and 1965 (In Four Parts) 3. Natural Gas. Inf. Circ. 8403, 1969, 8 pp.

Crump, Lulie H. and Phillip N. Yasnowsky. Supply and Demand for Energy in the United States by States and Regions, 1960 and 1965 (In Four Parts). 4. Petroleum and Natural Gas Liquids. Inf. Circ. 8411, 1969, 25 pp.

Hall, Franklin P. and Grace N. Broderick. Supply and Demand for Energy in the United States by States and Regions, 1960 and 1965 (In Four Parts) 2. Utility Electricity. Inf. Circ. 8402, 1969, 11 pp.

Research findings indicate that bromotrifluoromethane (Halon 1301) is a relatively effective fire extinguishant for gas- or liquid-fired flame, but is relatively ineffective on fires in coalbeds except for its inhibition of the carbon monoxide to carbon dioxide reaction.

Other research included investigation of radiation intensity distribution for the cross section of a laser beam, the determination of the minimum ignition energy for different size coal particles in that beam, and the determination of minimum air velocities required to disperse Pittsburgh-seam coal dustbeds.

Helium Conservation.—The helium conservation program in 1968 stressed the maximum beneficial use of helium resources in the United States for production and sale of helium for current use, the acquisition and storage of helium that would otherwise be wasted when helium-bearing natural gas is used for fuel, and helium-oriented research and development. Acquisition and storage of helium is aimed at assuring a reserve supply after presently known helium resources are depleted. Research is presently focused on improving processes and reducing costs of helium analysis, extraction, and purification, and on improving liquid-helium handling technology.

LEGISLATION AND GOVERNMENT PROGRAMS

Much of Government legislative activity in 1968 with respect to the minerals and mineral fuels industries was directed to coal mine safety, with auxiliary thrusts focused on solid waste disposal, gas pipeline safety measures, and expanded wilderness areas which contain reserve mineral deposits.

Several bills were introduced in the 90th Congress during late 1968 to strengthen existing legislation in coal mine safety. Special emphasis was directed to more frequent mine inspection, distinction between gassy and nongassy mines, and authority to instantly close down potentially hazardous mines. However, these bills lapsed with the adjournment of that Congress in mid-October.

Some pieces of legislation passed by the 90th Congress indirectly affect Bureau of Mines operations. Public Law 574 extended the Solid Waste Disposal Act through 1970. The Gas-Pipeline Safety Law, designated as Public Law 481, gave the Secretary of Transportation authority to regulate pipeline installations. The natural gas industry was requested to conform with regulations with respect to bringing interim construction and continuing construction of lines up to prescribed standards. The passage of the Expanded Wilderness Act (in the form of six interrelated laws) contained certain provisions with respect to additional wilderness areas to be set aside for conservation purposes, and prescribed particular provisions with respect to mineral deposits.

Major legislation in 1968 with respect to the national economy centered on the 10-percent tax surcharge. Congress was reluctant to enact tax legislation in the last half of 1967 and the first half of 1968, believing that the economy was not expanding at an excessive rate. The first impact of this delayed approval of tax enactment was further strong and inappropriate expansion. The evidence of excessive demand, rising prices, and deteriorating trade balance was compelling, and these developments together with the international financial crisis in March 1968 and the mid-May acceleration of interest rates to record high levels prompted Congress to pass the Revenue and Expenditure Control Act of 1968, which was signed into law by the President on June 28.

With respect to the national stockpile program, strategic materials held in Government inventories at yearend 1968 amounted to $69 billion at acquisition cost, essentially the same as in 1967, and approximately the same amount when calculated at market value. Of the total materials in Government inventories, $3.6 billion at cost, or $3.3 billion at estimated market value, were considered to be in excess of conventional stockpile objectives. Over 78 percent of the market value of that excess was made up of 11 materials: Aluminum, bauxite (Jamaica and Surinam), metallurgical-grade chromite, cobalt, industrial diamond stones, lead, metallurgical-grade manganese, nickel, tin, tungsten, and zinc. Major mineral stockpile items sold in 1968 were aluminum, metallurgical chromite, cobalt, silver, mercury, tungsten, and zinc. During 1968, Congress authorized the disposal of beryl ore and magnesium valued at $40 million. Total stockpile disposal of mineral commodities during calendar year 1968 was valued at $224.5 million, or 23 percent less than in 1967.

Continued exploration for new domestic sources of strategic and critical mineral commodities was encouraged by Government assistance under the Office of Minerals Exploration (OME) program. During fiscal 1968, 18 contracts representing Government funding of $0.7 million were executed. The principal commodities toward which the program was directed were gold, silver, mercury, and copper. This program, initiated in behalf of small mine operators, has been an important factor in maintaining adequate supplies of vital minerals.

WORLD REVIEW

World Economy.—Gross national product (GNP) in the major industrial countries continued to rise during 1968, but the rates of growth varied widely among countries. In Japan the current GNP rose 18.5 percent while in Canada the increase was 8.5 percent. United States GNP rose 9 percent in money terms and 5 percent in real terms. Industrial production similarly increased at widely varying rates, with Japan again experiencing the largest increase. Japanese industrial production rose 17.3 percent in 1968, and German industrial production rose 12.3 percent. In contrast, the U.S. increase in industrial production was 4.5 percent.

World Production.—Gains were made in world output of minerals and mineral fuels, especially for metallic ores and for metals, smelter basis (see table 63). Increases in U.S. production of metallic ores and smelter output of metals, as a percentage of total world production, were mixed. For some of the more important categories, such as iron ore, bauxite, aluminum, and magnesium, the percentage represented by U.S. production was down slightly or unchanged. For smelter tin and zinc, the percentage represented by U.S. production was up. World production of the majority of important nonmetallic minerals was up. Production of nitrogen and phosphate rock rose 14 and 7 percent, respectively, while that for potash and elemental sulfur showed considerably less increase. Crude petroleum production showed the biggest increase in the last several years, reaching a total of 14.1 billion barrels, 9.3 percent more than in 1967.

World Trade.—Mineral trade grew at a moderate rate in 1967 (the latest year for which data are available). Value of world trade in metals, metal ores and scrap, and mineral fuels grew 6 percent in 1967, to a total of $44 billion. Total mineral exports from the United States increased moderately in 1967; exports from Europe increased at a relatively slower rate. Within Europe, the European Economic Community enjoyed a greater rise in exports than the European Free Trade Association. Exports from both trade groups increased more slowly than U.S. exports. Mineral fuels continued to constitute a large part of world mineral trade.

World Prices.—World export price indexes for metal ores were unchanged in 1968 compared with 1967, but for mineral fuels they were down 1 index point (table 64). The quarterly indexes for metal ores showed a marked rise in the first quarter, while for the last three quarters prices fell below those of 1967. For mineral fuels, the quarterly indexes showed a falling off in price after the first quarter. Export prices of total minerals were down slightly in the more developed nations, and unchanged in the less developed countries. Prices for nonferrous base metals were moderately up in both the more developed and the less developed nations.

Table 1.—Value of mineral production, imports, and exports, by groups

(Millions)

Mineral group [1]	1964			1965			1966			1967			1968		
	Production	Imports	Exports	Production	Imports	Exports	Production	Imports	Exports	Production	Imports	Exports	Production	Imports	Exports
Metals and nonmetals except fuels:															
Nonmetals	$4,623	$323	$141	$4,933	$354	$185	$5,176	$412	$228	[r] $5,206	$414	$241	$5,452	$490	$246
Metals	2,366	917	151	2,544	973	154	2,703	1,192	158	2,333	[r] 1,117	171	2,703	1,160	241
Total	6,989	1,240	292	7,477	1,327	339	7,879	1,604	386	[r] 7,539	[r] 1,531	412	8,155	1,650	487
Mineral fuels	13,623	1,250	471	14,047	1,295	487	[r] 15,088	1,311	490	[r] 16,195	1,289	[r] 601	16,820	1,430	546
Grand total [2]	20,612	2,490	763	21,524	2,622	826	[r] 22,968	2,915	876	[r] 23,734	[r] 2,820	[r] 1,013	24,974	3,080	1,033

[r] Revised.
[1] For details, see the "Statistical Summary" chapter of this volume.
[2] Data may not add to total shown, because of rounding.

Table 2.—Value of mineral production by group, 1957–59 constant dollars[1]

(Millions)

Mineral group	1964	1965	1966	1967 [r]	1968
Metals and nonmetals except fuels:					
Nonmetals	$4,537	$4,836	$4,972	$4,930	$5,086
Metals	2,098	2,132	2,258	1,949	2,138
Total	6,635	6,968	7,230	6,879	7,224
Mineral fuels	13,831	14,232	15,082	15,987	16,410
Grand total	20,466	21,200	22,312	22,866	23,634

[r] Revised.
[1] Value deflated by the index of implicit unit value.

Table 3.—Indexes of the physical volume of mineral production, by group and subgroup

(1957–59 = 100)

	1964	1965	1966	1967	1968 [p]
Metals:					
Ferrous	108.3	110.4	119.1	109.0	111.2
Nonferrous:					
Base	125.8	135.8	142.2	102.5	123.4
Monetary	92.0	105.0	112.5	92.7	91.1
Other	114.3	98.2	98.1	111.4	122.4
Average	119.4	124.1	129.2	103.3	119.4
Average, all metals	113.9	117.3	124.2	106.1	115.4
Nonmetals:					
Construction	126.2	129.9	136.5	132.4	136.4
Chemical	132.1	151.8	167.1	172.6	170.7
Other	119.0	127.9	136.0	129.7	130.6
Average	126.9	133.5	141.7	139.1	141.9
Fuels:					
Coal	108.2	112.6	116.4	119.8	118.3
Crude oil and natural gas [1]	113.8	116.6	124.0	131.6	137.3
Average	114.0	117.3	124.1	131.1	135.8
Average, all minerals	116.7	120.7	127.8	130.5	135.2

[p] Preliminary.

[1] Does not cover isopentane, LP gases, and other natural gas liquids.

Table 4.—Federal Reserve Board indexes of industrial production, mining and selected mineral and mineral fuels related industries

(1957–59 = 100)

	1964	1965	1966	1967	1968 [p]
Mining:					
Coal	107.1	113.3	117.0	120.4	117.8
Crude oil and natural gas:					
Crude oil	109.9	111.9	119.3	126.3	130.6
Gas and gas liquids	136.1	143.0	152.0	163.5	172.6
Average [1]	110.4	112.3	118.0	123.1	126.5
Average coal, oil, and gas	109.8	112.5	117.8	122.7	125.0
Metal	117.4	124.2	133.4	120.3	126.4
Stone and earth minerals	118.7	126.5	133.5	135.4	137.7
Average	118.1	125.5	133.5	128.9	132.9
Average mining	111.3	114.8	120.5	123.8	126.4
Industrial production:					
Primary metals	129.1	137.6	142.7	132.5	137.3
Iron and steel	126.5	133.6	136.2	126.8	131.0
Nonferrous metals and products	138.3	152.2	166.2	153.2	160.1
Clay, glass, and stone products	126.0	133.5	140.7	138.7	146.2
Average industrial production	132.3	143.4	156.3	158.1	165.4

[p] Preliminary.

[1] Includes oil and gas drilling.

Source: Board of Governors of the Federal Reserve System. Federal Reserve Bulletin. February–June 1969. A description and historical data are available in Business Indexes, Industrial Production, 1957–59 Base, published by Federal Reserve Board, monthly.

Table 5.—Federal Reserve Board monthly indexes of mining production, seasonally adjusted

(1957–59 =100)

Month	Total mining [1]		Coal, oil and gas		Coal		Crude oil and natural gas						Metal, stone and earth materials		Metal mining		Stone and earth materials	
							Total [2]		Crude oil		Gas and gas liquids							
	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968
January	123.2	121.6	119.8	121.9	120.7	113.4	119.7	123.6	121.0	127.4	158.4	NA	139.4	120.3	140.3	100.0	138.7	135.3
February	122.4	123.9	119.0	123.2	115.7	116.8	119.6	124.5	120.0	129.7	160.0	NA	138.9	127.0	142.1	102.8	136.6	145.0
March	121.5	126.2	117.6	126.0	115.1	126.0	118.1	126.0	120.1	130.9	156.7	NA	140.0	127.4	143.7	108.7	137.2	141.2
April	122.0	127.1	118.5	124.7	125.5	124.4	117.1	124.8	119.6	128.7	161.5	NA	138.7	138.3	149.5	139.9	130.6	137.1
May	120.2	126.9	118.0	125.6	120.1	120.4	117.5	126.6	119.6	131.2	161.3	NA	130.8	133.5	132.9	131.4	129.2	135.0
June	123.8	129.2	121.7	128.1	122.5	126.7	121.6	128.4	123.6	132.4	167.3	NA	133.6	134.3	133.9	130.8	133.3	136.9
July	128.0	130.0	128.0	128.7	122.6	126.6	129.1	129.2	133.9	134.0	NA	NA	127.7	135.8	119.7	134.1	133.7	137.1
August	127.8	129.4	128.8	127.9	117.2	121.3	131.2	129.3	138.0	134.8	NA	NA	123.4	136.2	105.7	134.5	136.6	137.5
September	124.5	127.0	125.6	125.8	116.6	120.8	127.4	126.8	133.1	131.2	166.4	NA	119.3	132.8	96.2	127.7	136.5	136.5
October	122.8	120.7	124.2	118.9	115.3	86.6	126.0	125.5	130.3	129.1	166.8	NA	116.4	129.2	94.1	125.1	132.9	132.2
November	124.1	126.4	125.0	124.6	117.2	115.9	126.5	126.3	128.7	128.6	167.9	NA	120.1	135.3	94.6	135.1	139.0	135.5
December	122.8	127.4	122.7	124.2	119.2	118.3	123.5	125.4	126.4	126.4	165.3	NA	123.3	143.0	97.1	137.6	142.7	147.0
Average	123.8	p 126.3	122.7	p 125.0	120.4	p 118.1	123.1	p 126.4	126.3	p 130.4	163.5	NA	128.9	p 132.8	120.3	p 125.6	135.4	p 138.0

p Preliminary. NA Not available.

[1] Including fuels.

[2] Total includes oil and gas drilling.

Source: Board of Governors of Federal Reserve System. Federal Reserve Bulletin. March 1968–April 1969.

Table 6.—Production of mineral energy resources and electricity from hydropower and nuclear power

(Trillion Btu)

Year	Anthracite	Bituminous coal and lignite	Natural gas, wet (unprocessed)	Crude[1] petroleum	Electricity[2]		Total
					Hydropower	Nuclear power	
1964	436	12,759	17,056	15,690	1,861	34	47,836
1965	378	13,417	17,652	15,930	2,051	39	49,467
1966	329	13,988	18,894	16,925	2,062	58	52,256
1967	311	14,479	20,087	18,098	2,344	81	55,400
1968 p	291	14,279	21,372	18,880	2,352	130	57,304

p Preliminary.

[1] Heat values employed for crude petroleum are 1964, 5,630,254 Btu per barrel; 1965, 5,531,000 Btu; 1966, 5,257,440 Btu; 1967, 5,628,540 Btu; and 1968, 5,671.420 Btu.

[2] Hydropower and nuclear power include installations owned by manufacturing plants and mines as well as Government and privately owned public utilities. The fuel equivalent of hydropower and nuclear power is calculated from the kilowatt-hours produced, converted to theoretical energy resources inputs calculated from prevailing average heat rates at central electric stations, using 10,504 Btu per kilowatt-hour in 1964, 10,530 Btu in 1965, 10,586 Btu in 1966, 10,582 Btu in 1967, and 10,582 Btu in 1968.

Table 7.—Consumption of major mineral products, mineral fuels, and electricity, 1967, 1968, and projections

Commodity	1967	1968 p	Projections [1]	Average annual growth rate 1947–65 (percent)	Projected average annual growth rate [1] (percent)
MINERAL PRODUCTS					
Ferrous metals:					
Iron ore ..... thousand long tons	127,424	131,753	176,000	+0.8	+1.6
Raw steel (production) ..... thousand short tons	127,213	131,462	162,000	+1.5	+1.1
Chromite ores (gross weight):					
Metallurgical grade ..... do	866	796	2,100	+4.0	+5.5
Refractory grade ..... do	310	310	260	+.8	−2.8
Chemical grade ..... do	179	202	280	+2.0	+1.8
Manganese ore (35 percent or more Mn) ..... do	2,383	2,228	3,250	+1.9	+2.1
Molybdenum (Mo content) ..... thousand pounds	49,506	49,271	132,000	[2] +5.2	+5.6
Tungsten (W content) ..... do	13,860	11,038	36,800	+3.6	+6.9
Nonferrous metals:					
Aluminum (apparent consumption) ..... thousand short tons	4,009	4,656	12,300	+7.4	+5.5
Antimony, primary ..... short tons	17,350	18,520	23,000	−1.5	+1.2
Copper, refined [3] ..... thousand short tons	1,936	1,880	3,750	+1.0	+3.8
Lead, primary and secondary ..... do	1,261	1,329	1,430	.0	+.4
Zinc, all classes ..... do	1,592	1,728	3,000	+1.3	+3.1
Mercury, primary ..... 76-pound flasks	47,367	41,042	67,000	+3.4	+2.7
Platinum-group metals ..... thousand troy ounces	1,334	1,368	4,013	+6.9	+6.1
Silver (industrial consumption) ..... do	171,031	145,293	332,000	NA	+4.7
Ilmenite and titanium slag (estimated TiO_2 content) ..... short tons	575,181	610,944	1,500,000	+4.8	+5.1
Uranium (U_3O_8 content, production) ..... do	9,125	12,338	46,000–74,000	+4.9	+7.5 to +10.8
Nonmetals:					
Asbestos (apparent consumption) ..... thousand short tons	721	817	1,314	+.8	+2.6
Cement (production) ..... million barrels	378	403	890	+3.7	+4.5
Clays (apparent consumption) ..... thousand short tons	53,623	55,811	79,700	+2.1	+1.8
Lime (sold or used) ..... do	17,974	18,637	52,000	+5.3	+5.8
Phosphate rock (P content, apparent consumption) ..... do	3,826	3,475	8,800–15,500	+4.9	+5.2 to +8.6
Potash (K content, apparent consumption) ..... do	3,385	3,500	8,400–15,500	+6.4	+4.7 to +8.6
Salt (apparent consumption) ..... do	41,111	44,002	88,000	+4.6	+3.9
Sand and gravel ..... million short tons	907	917	1,510	[4] +4.2	+2.8
Stone, crushed (sold or used) ..... do	784	816	1,310	+8.1	+2.6
Sulfur, all forms (apparent consumption) ..... thousand long tons	9,301	9,091	23,000–37,000	+3.0	+5.3 to +8.1
MINERAL ENERGY RESOURCES AND ELECTRICITY [5]					
Bituminous coal ..... million short tons	480	499	755–925	−1.1	+2.5 to +3.7
Coal carbonized for coke [6] ..... do	(92)	(91)	(90)	(−.6)	(−.1)
Anthracite ..... do	11	10	5	−7.1	−8.9
Petroleum, including natural gas liquids ..... million barrels	4,585	4,900	8,000	+4.3	+2.7
Natural gas, dry [7] ..... billion cubic feet	17,685	18,957	31,000	+7.3	+2.6
Electricity generation, net ..... million kilowatt-hours	1,317,301	1,432,999	NA	+7.6	NA
Utilities ..... do	1,214,365	1,326,930	3,560,000	+8.2	+5.6
Hydropower [8] ..... do	221,219	222,238	376,000	+1.9	+2.9
Nuclear power ..... do	7,655	12,326	792,000–1,256,000	[9] +54.0	([10])

See footnotes at end of table.

Table 7.—Consumption of major mineral products, mineral fuels, and electricity, 1967, 1968, and projections—Continued

Commodity	1967	1968 p	Projections [1]	Average annual growth rate 1947–65 (percent)	Projected average annual growth rate [1] (percent)
Electricity generation, net—Continued					
Utilities—Continued					
Conventional fuel-burning plants million kilowatt-hours	985,192	1,092,366	1,928,000–2,392,000	+9.2	+3.2 to +4.4
Industrial do	102,935	106,069	NA	+3.9	NA
Total energy resources inputs trillion Btu	58,858	62,308	110,300	+2.7	+3.2

---

p Preliminary. NA Not available.

[1] All projections are for the year 1985. Projected average annual growth rates, which reflect annual percent compounded, are for 1968 through 1985.

[2] Growth rate 1956–65.

[3] Changed from withdrawals from total supply to refined copper consumption.

[4] Growth rate 1954–65.

[5] Morrison, Warren E., and Charles L. Readling. An Energy Model for the United States, Featuring Energy Balances for the Years 1947 to 1965 and Projections and Forecasts to the Years 1980 and 2000. BuMines Inf. Cir. 8384, 1968, 127 pp.

[6] Figures in parenthesis are not added into totals.

[7] Residue gas excludes extraction loss but includes transmission loss.

[8] Net generation, adjusted for net imports or exports. The bulk of net trade is hydropower with an undetermined amount of steam plant power.

[9] Growth rate 1957–65.

[10] Over 10 percent.

Table 8.—Calculated gross consumption of mineral energy resources, and electricity from hydropower and nuclear power in British thermal units (Btu), and percent contributed by each[1]

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry	Petroleum (excluding natural gas liquids)	Natural gas liquids	Electricity		Total
						Hydropower	Nuclear power	
TRILLION BTU								
1964	365	11,295	15,562	20,590	1,796	1,873	34	51,515
1965	328	12,030	16,098	21,364	1,877	2,049	39	53,785
1966	290	12,740	17,393	22,405	1,989	2,073	58	56,948
1967	274	12,587	18,250	23,191	2,144	2,341	81	58,868
1968 p	258	13,069	19,564	24,758	2,286	2,359	130	62,424
PERCENT								
1964	0.7	21.9	30.2	40.0	3.5	3.6	0.1	100.0
1965	.6	22.4	29.9	39.7	3.5	3.8	.1	100.0
1966	.5	22.4	30.5	39.4	3.5	3.6	.1	100.0
1967	.5	21.4	31.0	39.4	3.6	4.0	.1	100.0
1968 p	.4	20.9	31.3	39.7	3.7	3.8	.2	100.0

p Preliminary.

[1] Heat values employed are anthracite, 12,700 Btu per pound; bituminous coal and lignite, 13,100 Btu per pound. Weighted average British thermal units for petroleum products obtained by using 5,248,000 gasoline and naphtha-type jet fuel, 5,670,000 kerosine and kerosine-type jet fuel, 5,825,000 distillate, 6,287,000 residual, 6,064,800 lubricants, 5,537,280 wax, 6,636,000 asphalt, and 5,796,000 miscellaneous; natural gas dry, 1,035 Btu per cubic foot in 1964, 1,032 Btu thereafter; natural gas liquids weighted average British thermal units in 1964 and 1965 based on production of natural gasoline and cycle products at 110,000 Btu per gallon, and LP gas, including ethane, at 95,000 Btu per gallon; 1966 and thereafter ethane production converted at 73,390 Btu per gallon. Hydropower (adjusted for net imports or net exports) and nuclear power are derived from net electricity generated, converted to theoretical energy resources inputs calculated from prevailing average heat rates at central electric stations using 10,504 Btu per kilowatt-hour in 1964, 10,530 Btu in 1965, 10,586 Btu in 1966, 10,582 Btu in 1967, and 10,582 Btu in 1968.

Table 9.—Gross consumption of energy resources, by major sources and consuming sectors [1]

(Trillion Btu)

Year	Anthracite	Bituminous coal and lignite	Natural gas, dry [1]	Petroleum [2]	Hydropower [3]	Nuclear power [3]	Total gross energy inputs [4]	Utility electricity purchased [5]	Total sector energy inputs [6]
HOUSEHOLD AND COMMERCIAL									
1964	[7] 191	560	5,314	5,190	--------	--------	11,255	1,795	13,050
1965	[7] 168	546	5,518	5,635	--------	--------	11,867	1,948	13,815
1966	143	575	5,945	5,766	--------	--------	12,429	2,101	14,530
1967	128	497	6,223	6,206	--------	--------	13,054	2,257	15,311
1968 [p]	121	447	6,451	6,581	--------	--------	13,600	2,469	16,069
INDUSTRIAL									
1964	[7] 115	5,362	7,397	4,184	--------	--------	17,058	1,544	18,602
1965	[7] 101	5,640	7,671	4,138	--------	--------	17,550	1,634	19,184
1966	88	5,806	8,203	4,352	--------	--------	18,449	1,788	20,237
1967	90	5,553	8,599	4,298	--------	--------	18,540	1,868	20,408
1968 [p]	80	5,536	9,258	4,474	--------	--------	19,348	2,043	21,391
TRANSPORTATION [8]									
1964	NA	20	448	11,791	--------	--------	12,259	17	12,276
1965	NA	19	517	12,179	--------	--------	12,715	18	12,733
1966	NA	18	553	12,777	--------	--------	13,348	16	13,364
1967	NA	14	594	13,542	--------	--------	14,150	17	14,167
1968 [p]	NA	12	610	14,513	--------	--------	15,135	18	15,153
ELECTRICITY GENERATION, UTILITIES [3]									
1964	57	5,353	2,403	636	1,873	34	10,356	3,356	--------
1965	55	5,825	2,392	744	2,049	39	11,104	3,600	--------
1966	56	6,341	2,692	905	2,073	58	12,125	3,905	--------
1967	55	6,523	2,884	1,018	2,341	81	12,847	4,142	--------
1968 [p]	56	7,074	3,245	1,181	2,359	130	14,045	4,530	--------
MISCELLANEOUS AND UNACCOUNTED FOR									
1964	[7] 2	--------	--------	585	--------	--------	587	--------	--------
1965	[7] 4	--------	--------	545	--------	--------	549	--------	--------
1966	3	--------	--------	594	--------	--------	597	--------	--------
1967	1	--------	--------	276	--------	--------	277	--------	--------
1968 [p]	1	--------	--------	295	--------	--------	296	--------	--------
TOTAL GROSS ENERGY INPUTS									
1964	365	11,295	15,562	22,386	1,873	34	51,515	--------	--------
1965	328	12,030	16,098	23,241	2,049	39	53,785	--------	--------
1966	290	12,740	17,393	24,394	2,073	58	56,948	--------	--------
1967	274	12,587	18,250	25,335	2,341	81	58,868	--------	--------
1968 [p]	258	13,069	19,564	27,044	2,359	130	62,424	--------	--------

[p] Preliminary. NA Not available.

[1] Excludes natural gas liquids.

[2] Petroleum products including still gas, LRG, and natural gas liquids.

[3] Represents outputs of hydropower (adjusted for net imports or net exports) and nuclear power converted to theoretical energy inputs calculated from prevailing average heat rates at central electric stations using 10,504 Btu per kilowatt-hour in 1964, 10,530 Btu in 1965, 10,586 Btu in 1966, 10,582 Btu in 1967, and 10,582 Btu in 1968. Excludes inputs for power generated by nonutility plants which are included within the other consuming sectors.

[4] Gross energy is that contained in all types of commercial energy at time it is incorporated in the economy, whether energy is produced domestically or imported. Gross energy comprises inputs of primary fuels (or the derivatives) and outputs of hydropower and nuclear power converted to theoretical energy inputs. Gross energy includes energy used for production, processing, and transportation of energy proper.

[5] Utility electricity, generated and imported, distributed to the other consuming sectors as energy resource inputs. Distribution to sectors is based on historical series in the Edison Electric Institute Yearbook. Conversion of electricity to energy equivalent by sectors was made at the value of contained energy corresponding to 100-percent efficiency using a theoretical rate of 3,412 Btu per kilowatt-hour.

[6] Energy resource inputs by sector, including direct fuels and electricity distributed.

[7] The household and commercial and industrial sectors include an estimated breakdown of undistributed energy formerly included under miscellaneous and unaccounted for.

[8] Includes bunkers and military transportation.

Table 10.—Estimated gross consumption of energy resources in the mineral and manufacturing industries, by major sources of energy within selected two-digit SIC industry groups, 1968 p

SIC code	Industry group	Anthracite		Bituminous coal and lignite		Natural gas, dry [1]	
		Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu	Billion cubic feet	Trillion Btu
20	Food and kindred products	145	3	8,480	260	575	593
26	Paper and allied products	263	7	14,888	460	330	341
28	Chemicals and allied products	263	7	21,483	659	1,181	1,219
29	Petroleum refining and related industries	--------	--------	(5)	(5)	981	1,012
32	Stone, clay, glass, and concrete products	79	2	13,003	404	435	449
33	Primary metal industries	2,085	53	99,313	2,785	836	863
	All mineral and other manufacturing industries	317	8	31,283	968	4,633	4,781
	Total	3,152	80	188,450	5,536	8,971	9,258

SIC code	Industry group	Petroleum [2]		Total gross energy inputs, trillion Btu	Utility electricity purchased [3]		Total sector energy inputs, trillion Btu [4]
		Million barrels	Trillion Btu		Billion kwhr	Trillion Btu'	
20	Food and kindred products	22	134	990	35.9	123	1,113
26	Paper and allied products	35	211	1,019	29.9	102	1,121
28	Chemicals and allied products	302	1,426	3,311	173.6	592	3,903
29	Petroleum refining and related industries	264	1,589	2,601	24.0	82	2,683
32	Stone, clay, glass, and concrete products	14	87	942	29.9	102	1,044
33	Primary metal industries	59	306	4,007	137.7	470	4,477
	All mineral and other manufacturing industries	116	721	6,478	167.7	572	7,050
	Total	812	4,474	19,348	598.7	2,043	21,391

---

p Preliminary.

[1] Excludes natural gas liquids.

[2] Petroleum products including still gas, LRG, and natural gas liquids.

[3] Utility electricity, generated and imported, distributed to the industrial sector as resources inputs. Distribution is based on historical series in the Edison Electric Institute Yearbook. Conversion of electricity to energy equivalent was made at the value of contained energy corresponding to 100-percent efficiency using a theoretical rate of 3,412 Btu per kilowatt-hour.

[4] Energy resource inputs, including direct fuels and electricity distributed.

[5] Included in "All mineral and other manufacturing industries."

Table 11.—Domestic supply and demand for coal

	1967		1968 p	
	Thousand short tons	Trillion Btu	Thousand short tons	Trillion Btu
ANTHRACITE				
Supply:				
Production [1]	12,256	311.3	11,461	291.1
Exports [2]	−1,422	−36.1	−1,301	−33.0
Imports	NA	NA	NA	NA
Stock change: withdrawals (+), additions (−)	----------	----------	----------	----------
Losses, gains, and unaccounted for	−34	−.9	----------	----------
Total	10,800	274.3	10,160	258.1
Demand by major consuming sectors: [3]				
Household and commercial [4]	5,035	127.9	4,759	120.9
Industrial [5]	3,529	89.6	3,152	80.1
Transportation [6]	(7)	(7)	(7)	(7)
Electricity generation, utilities	2,186	55.5	2,203	56.0
Miscellaneous and unaccounted for	50	1.3	46	1.1
Total	10,800	274.3	10,160	258.1
BITUMINOUS COAL AND LIGNITE				
Supply:				
Production [1]	552,626	14,478.8	545,000	14,279.0
Exports	−49,510	−1,297.2	−50,637	−1,326.7
Imports	227	5.9	155	4.1
Stock change: withdrawals (+), additions (−)	−18,600	−487.3	+11,105	+291.0
Losses, gains, and unaccounted for	−4,327	−113.3	−6,793	−178.1
Total	480,416	12,586.9	498,830	13,069.3
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial [4]	17,099	497.0	15,224	447.2
Industrial [5]	186,063	5,408.1	183,442	5,389.0
Coal carbonized for coke [8]	(92,272)	(2,682.0)	(90,765)	(2,666.4)
Transportation [6]	467	13.6	417	12.3
Electricity generation, utilities	271,784	6,522.8	294,739	7,073.7
Total	475,413	12,441.5	493,822	12,922.2
Raw material: Industrial: [9]				
Crude light oil	1,261	36.6	1,195	35.1
Crude coal tar	3,742	108.8	3,813	112.0
Total	5,003	145.4	5,008	147.1
Grand total	480,416	12,586.9	498,830	13,069.3

---

p Preliminary. NA Not available.

[1] Includes use by producers for power and heat.

[2] Includes shipments to U.S. Armed Forces in West Germany.

[3] Except for small quantities used as raw material for coal chemicals, all anthracite represents fuel and power.

[4] Data represent "retail deliveries to other consumers." These are mainly household and commercial users, with some unknown portion of use by small industries.

[5] Includes consumption by coke plants, steel and rolling mills, and other industrial uses.

[6] Includes bunkers and military transportation.

[7] Data not available. Believed to be small and of minor significance.

[8] Figures in parenthesis are not added into totals.

[9] Coal equivalent based on British thermal unit value of raw materials for coal chemicals.

Table 12.—Domestic supply and demand for natural gas

	1967		1968 p	
	Million cubic feet	Trillion Btu	Million cubic feet	Trillion Btu
Supply:				
Production [1]	18,171,325	20,086.9	19,322,400	21,372.4
Exports	—81,614	—84.2	—93,745	—96.7
Imports	564,226	582.3	651,885	672.7
Stock change: withdrawals (+), additions (—)	—184,829	—190.7	—95,539	—98.6
Transfers out, extraction loss [2]	—784,535	—2,143.8	—827,877	—2,286.0
Losses, gains, and unaccounted for	------------	------------	------------	------------
Total	17,684,573	18,250.5	18,957,124	19,563.8
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	6,029,855	6,222.8	6,250,997	6,451.0
Industrial [3]	7,885,653	8,138.0	8,530,331	8,803.3
Transportation	575,752	594.2	590,965	609.9
Electricity generation, utilities	2,746,352	2,834.2	3,143,858	3,244.5
Total	17,237,612	17,789.2	18,516,151	19,108.7
Raw material: Industrial: [4]				
Carbon black	108,961	112.5	104,973	108.4
Other chemicals [5]	338,000	348.8	336,000	346.7
Total	446,961	461.3	440,973	455.1
Grand total	17,684,573	18,250.5	18,957,124	19,563.8

---

p Preliminary.

[1] Marketed production includes wet gas sold or consumed by producers, losses in transmission, producers' additions to storage, and increases in gas pipeline fill; excludes repressuring and vented and wasted. British thermal unit value of production is for wet gas prior to extraction of natural gas liquids. Higher values assigned to extraction loss are reflected in value of production for each year.

[2] Extraction loss from cycling plants represents offtake of natural gas for natural gas liquids as reported to Bureau of Mines. Energy equivalent of extraction loss is based on annual outputs of natural gasoline and associated products at 110,000 Btu per gallon, annual outputs of LPG at 95,500 Btu per gallon, and annual outputs of ethane at 73,390 Btu per gallon. (Prior to 1967, ethane production was included with LPG in converting to Btu values.)

[3] Includes transmission losses of 296, 214 million cubic feet in 1967 and 325,062 million cubic feet in 1968.

[4] Includes some fuel and power used by raw materials industries.

[5] Estimated from partial data.

Table 13.—Domestic supply and demand for petroleum[1]

	1967		1968 [p]	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu
Supply:				
Crude oil:[2]				
Production	3,215.7	18,099.7	3,328.9	18,879.6
Exports	—26.5	—149.2	—1.8	—10.2
Imports	411.7	2,317.3	[3] 472.3	2,678.6
Stock change: withdrawals (+), additions (—)	—10.6	—59.7	—23.2	—131.5
Losses and transfers for use as crude	—7.7	—43.3	—1.8	—10.2
Total	3,582.6	20,164.8	3,774.4	21,406.3
Petroleum input runs to stills:				
Crude oil [2]	3,582.6	20,164.8	3,774.4	21,406.3
Transfers in, natural gas liquids [4]	244.8	1,131.0	259.4	1,198.4
Other hydrocarbons	----------	----------	3.4	19.0
Total	3,827.4	21,295.8	4,037.2	22,623.7
Output:				
Refined products	3,827.4	21,295.8	4,037.2	22,623.7
Unfinished oils, net	34.2	215.0	26.2	164.7
Overage or loss	106.6	593.1	116.7	654.0
Total	3,968.2	22,103.9	4,180.1	23,442.4
Imports	514.3	3,166.5	566.1	3,289.2
Exports	—85.5	—494.1	—83.4	—479.9
Stock change, including natural gas liquids	—52.4	—289.6	—32.2	—177.7
Transfers in, natural gas liquids [4] [5]	269.7	1,012.8	290.9	1,087.6
Losses, gains, and unaccounted for	—29.8	—164.7	—21.3	—117.5
Total	4,584.5	25,334.8	4,900.2	27,044.1
Demand by major consuming sectors:				
Fuel and power:				
Household and commercial	940.7	5,289.0	1,000.8	5,597.6
Industrial	470.9	2,819.9	480.6	2,874.0
Transportation [6]	2,497.1	13,407.7	2,674.9	14,367.3
Electricity generation, utilities	161.3	1,012.8	188.0	1,180.6
Other, not specified	32.8	187.9	34.8	196.5
Total	4,102.8	22,717.3	4,379.1	24,216.0
Raw material:[7]				
Petrochemical feedstock offtake	231.5	1,053.4	253.3	1,154.2
Other nonfuel use	234.2	1,475.7	249.9	1,575.1
Total	465.7	2,529.1	503.2	2,729.3
Miscellaneous and unaccounted for	16.0	88.4	17.9	98.8
Total	4,584.5	25,334.8	4,900.2	27,044.1

---

[p] Preliminary.

[1] Supply and demand for crude oil and petroleum products. Petroleum products include products refined and processed from crude oil, including still gas and LRG; also natural gas liquids transferred from natural gas.

[2] Btu value for crude oil for each year shown is based on average British thermal unit value of total output of petroleum products (including refinery fuel and losses) adjusted to exclude natural gas liquids inputs and their implicitly derived values. Value for net imports of crude is based on the average value of crude runs to stills.

[3] Includes some Athabasca hydrocarbons.

[4] Btu values for natural gas liquids for each year shown are implicitly derived from weighted averages of production of major natural gas liquids, derived by converting natural gasoline and cycle products at 110,000 Btu per gallon, LPG at 95,000 Btu per gallon, and ethane at 73,390 Btu per gallon.

[5] Includes natural gas liquids other than those channeled into refinery input as follows: Petrochemical feedstocks, direct uses for fuel and power, and other uses.

[6] Includes bunkers and military transportation.

[7] Includes some fuel and power used by raw materials industries.

Table 14.—Petroleum consumption, by major products and by major consuming sectors[1]

	Household and commercial		Industrial		Transportation[2]		Electricity generation, utilities		Miscellaneous and unaccounted for		Total domestic product demand	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu
1967												
Fuel and power:												
Liquefied gases	148.1	594.0	17.4	69.8	27.7	111.1	--------	--------	3.7	14.9	196.9	789.8
Jet fuels:												
Naphtha type	--------	--------	--------	--------	111.6	597.6	--------	--------	--------	--------	111.6	597.6
Kerosine type	--------	--------	--------	--------	189.2	1,072.8	--------	--------	--------	--------	189.2	1,072.8
Total	--------	--------	--------	--------	300.8	1,670.4	--------	--------	--------	--------	300.8	1,670.4
Gasoline	--------	--------	--------	--------	1,842.7	9,670.5	--------	--------	--------	--------	1,842.7	9,670.5
Kerosine	68.5	388.4	31.6	179.2	--------	--------	--------	--------	--------	--------	100.1	567.6
Distillate fuel	532.0	3,098.9	59.8	348.3	201.7	1,174.9	2.9	16.9	21.7	126.4	818.1	4,765.4
Residual fuel	192.1	1,207.7	169.8	1,067.5	124.2	780.8	158.4	995.9	7.4	46.6	651.9	4,098.5
Still gas	--------	--------	140.0	840.0	--------	--------	--------	--------	--------	--------	140.0	840.0
Petroleum coke	--------	--------	52.3	315.1	--------	--------	--------	--------	--------	--------	52.3	315.1
Total	940.7	5,289.0	470.9	2,819.9	2,497.1	13,407.7	161.3	1,012.8	32.8	187.9	4,102.8	22,717.3
Raw material:[3]												
Special naphthas	--------	--------	25.2	132.2	--------	--------	--------	--------	--------	--------	25.2	132.2
Lubes[4] and waxes	--------	--------	25.9	155.1	22.1	134.0	--------	--------	--------	--------	48.0	289.1
Petroleum coke[5]	--------	--------	22.8	137.3	--------	--------	--------	--------	--------	--------	22.8	137.3
Asphalt and road oil	138.2	917.1	--------	--------	--------	--------	--------	--------	--------	--------	138.2	917.1
Petrochemical feedstock offtake:												
Liquefied refinery gas	--------	--------	44.0	176.5	--------	--------	--------	--------	--------	--------	44.0	176.5
Liquefied petroleum gas[6]	--------	--------	103.6	415.5	--------	--------	--------	--------	--------	--------	103.6	415.5
Naphtha (−400 degrees)	--------	--------	50.3	264.0	--------	--------	--------	--------	--------	--------	50.3	264.0
Still gas	--------	--------	9.5	57.0	--------	--------	--------	--------	--------	--------	9.5	57.0
Miscellaneous (+400 degrees)	--------	--------	24.1	140.4	--------	--------	--------	--------	--------	--------	24.1	140.4
Total	138.2	917.1	305.4	1,478.0	22.1	134.0	--------	--------	--------	--------	465.7	2,529.1
Miscellaneous and unaccounted for	--------	--------	--------	--------	--------	--------	--------	--------	16.0	88.4	16.0	88.4
Total domestic product demand	1,078.9	6,206.1	776.3	4,297.9	2,519.2	13,541.7	161.3	1,012.8	48.8	276.3	4,584.5	25,334.8
1968 p												
Fuel and power:												
Liquefied gases	171.1	686.3	20.8	83.4	30.0	120.3	--------	--------	3.4	13.7	225.3	903.7
Jet fuel:												
Naphtha type	--------	--------	--------	--------	126.6	678.5	--------	--------	--------	--------	126.6	678.5

See footnotes at end of table.

Table 14.—Petroleum consumption, by major products and by major consuming sectors [1]—Continued

	Household and commercial		Industrial		Transportation [2]		Electricity generation, utilities		Miscellaneous and unaccounted for		Total domestic product demand	
	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu	Million barrels	Trillion Btu
1968 [p]												
Fuel and power—Continued												
Jet fuel—Continued												
Kerosine type	--------	--------	--------	--------	221.7	1,259.5	--------	--------	--------	--------	221.7	1,259.5
Total	--------	--------	--------	--------	348.3	1,938.0	--------	--------	--------	--------	348.3	1,938.0
Gasoline	--------	--------	--------	--------	1,955.8	10,264.8	--------	--------	--------	--------	1,955.8	10,264.8
Kerosine	78.7	446.2	23.5	133.2	--------	--------	--------	--------	.9	5.1	103.1	584.5
Distillate fuel	555.0	3,232.8	61.3	357.1	212.9	1,240.1	3.0	17.5	30.5	177.7	862.7	5,025.2
Residual fuel	196.0	1,232.3	171.0	1,075.0	127.9	804.1	185.0	1,163.1	--------	--------	679.9	4,274.5
Still gas	--------	--------	149.8	898.8	--------	--------	--------	--------	--------	--------	149.8	898.8
Petroleum coke	--------	--------	54.2	326.5	--------	--------	--------	--------	--------	--------	54.2	326.5
Total	1,000.8	5,597.6	480.6	2,874.0	2,674.9	14,367.3	188.0	1,180.6	34.8	196.5	4,379.1	24,216.0
Raw material: [3]												
Special naphthas	--------	--------	27.0	141.7	--------	--------	--------	--------	--------	--------	27.0	141.7
Lubes [4] and waxes	--------	--------	28.5	170.5	24.1	146.2	--------	--------	--------	--------	52.6	316.7
Petroleum coke [5]	--------	--------	22.1	133.2	--------	--------	--------	--------	--------	--------	22.1	133.2
Asphalt and road oil	148.2	983.5	--------	--------	--------	--------	--------	--------	--------	--------	148.2	983.5
Petrochemical feedstock offtake:												
Liquefied refinery gas	--------	--------	46.5	186.5	--------	--------	--------	--------	--------	--------	46.5	186.5
Liquefied petroleum gas [6]	--------	--------	113.9	456.9	--------	--------	--------	--------	--------	--------	113.9	456.9
Naphtha (−400 degrees)	--------	--------	55.6	291.8	--------	--------	--------	--------	--------	--------	55.6	291.8
Still gas	--------	--------	9.8	58.8	--------	--------	--------	--------	--------	--------	9.8	58.8
Miscellaneous (+400 degrees)	--------	--------	27.5	160.2	--------	--------	--------	--------	--------	--------	27.5	160.2
Total	148.2	983.5	330.9	1,599.6	24.1	146.2	--------	--------	--------	--------	503.2	2,729.3
Miscellaneous and unaccounted for	--------	--------	--------	--------	--------	--------	--------	--------	17.9	98.8	17.9	98.8
Total domestic product demand	1,149.0	6,581.1	811.5	4,473.6	2,699.0	14,513.5	188.0	1,180.6	52.7	295.3	4,900.2	27,044.1

---

[p] Preliminary.

[1] Includes liquefied refinery gas and natural gas liquids.

[2] Includes bunkers and military transportation.

[3] Includes some fuel and power used by raw materials industries.

[4] Lubricants are distributed equally between the Industrial and Transportation sectors.

[5] Includes portions of petroleum coke estimated to be consumed in nonfuel uses.

[6] Includes LPG for synthetic rubber.

Table 15.—Electrical energy sales to ultimate consumers

(Million kilowatt-hours)

Region	Total consumption	Residential	Industrial and commercial	Total consumption	Residential	Industrial and commercial
		1964			1965	
New England	34,207	12,013	20,889	36,984	12,813	22,806
Middle Atlantic	135,255	36,152	89,898	145,248	38,850	96,783
East North-Central	182,871	49,058	126,920	193,539	52,544	133,919
West North-Central	57,500	22,570	32,973	61,335	23,864	35,458
South Atlantic	120,891	41,482	75,004	132,883	45,178	82,932
East South-Central	102,776	25,489	75,988	106,314	26,811	78,118
West South-Central	83,938	25,100	54,574	92,586	27,396	60,602
Mountain	41,045	10,957	28,332	43,086	11,445	29,913
Pacific	129,026	38,150	86,576	138,376	40,939	93,085
Alaska and Hawaii	2,847	1,039	1,741	3,063	1,130	1,861
Total United States	890,356	262,010	592,895	953,414	280,970	635,477
		1966			1967	
New England	40,184	13,883	24,877	43,361	15,437	26,496
Middle Atlantic	156,302	42,088	104,153	164,125	45,410	108,184
East North-Central	207,521	57,005	142,858	219,554	61,238	149,630
West North-Central	66,030	25,303	38,579	71,481	27,138	41,950
South Atlantic	148,757	50,920	92,723	161,567	55,692	99,916
East South-Central	112,594	29,589	81,463	115,851	31,166	83,027
West South-Central	102,760	29,753	68,071	113,125	32,739	74,872
Mountain	47,198	12,313	33,100	49,342	13,157	33,774
Pacific	154,302	44,502	103,093	164,998	48,210	108,502
Alaska and Hawaii	3,334	1,216	2,038	3,619	1,338	2,184
Total United States	1,038,982	306,572	690,955	1,107,023	331,525	728,535

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utility Industry. 1964 through 1967.

Table 16.—Net supply of principal minerals, by components[1]

(Thousand short tons of mineral content, unless otherwise stated)

Commodity, and mineral content measured	Total net supply			Components as percent of total, before subtracting exports						Exports as percent of gross supply	
	1967	1968	Percent increase	Primary shipments		Old scrap		Imports		1967	1968
				1967	1968	1967	1968	1967	1968		
FERROUS METALS											
Iron ore	r 121,120	119,991	−1	65	65	--------	--------	35	35	7	5
Pig iron	r 87,417	89,860	3	99	99	--------	--------	1	1	--------	--------
Steel ingot	r 136,592	148,856	9	92	88	--------	--------	8	12	2	2
Chromite (Cr₂O₃)	494	436	−12	--------	--------	--------	--------	100	100	15	14
Cobalt	r 10	9	−10	64	58	--------	--------	36	42	10	33
Manganese	r 1,002	862	−14	4	1	--------	--------	96	99	1	2
Molybdenum	r 26	33	27	100	98	--------	--------	--------	2	58	45
Nickel	173	171	−1	14	11	7	5	79	84	4	4
Tungsten	r 9	11	22	90	91	--------	--------	10	8	11	9
OTHER METALS											
Aluminum	r 3,441	3,996	16	83	78	3	4	14	18	11	9
Antimony	43	36	−16	2	3	56	67	42	30	--------	--------
Beryl ore (BeO) ... short tons	1,046	434	−59	W	4	--------	--------	100	96	--------	--------
Cadmium	r 6	7	17	71	75	--------	--------	29	25	17	14
Copper	r 2,035	2,406	18	46	48	23	21	31	31	3	3
Lead	r 1,382	1,340	−3	23	27	40	41	37	32	1	1
Magnesium	110	105	−5	82	85	11	12	7	3	12	17
Mercury ... 76-pound flasks	r 67,655	79,004	17	34	33	31	40	85	27	4	9
Platinum-group ... thousand troy ounces	r 1,437	1,718	20	2	1	21	16	77	83	19	23
Tin ... thousand long tons	r 72	76	6	--------	--------	30	29	70	71	7	11
Titanium concentrate (TiO₂):											
Ilmenite and slag	608	671	11	76	75	--------	--------	24	25	1	1
Rutile	148	157	6	W	W	--------	--------	100	100	2	--------
Uranium concentrate (U₃O₈)	10	12	20	90	100	--------	--------	10	(2)	--------	--------
Zinc	1,293	1,370	6	42	38	8	7	50	55	1	2
NONMETALS											
Asbestos	721	818	13	16	14	--------	--------	84	86	7	5
Barite, crude	1,494	1,590	6	64	58	--------	--------	36	42	--------	--------
Bromine	146	152	4	100	100	--------	--------	--------	--------	--------	--------
Clays	53,623	55,810	3	100	100	--------	--------	--------	--------	2	4
Fluorspar, finished	r 1,198	1,289	8	25	19	--------	--------	75	81	(2)	1
Gypsum	r 21,798	24,299	11	79	78	--------	--------	21	22	(2)	(2)
Mica (except scrap)	r 91	98	8	99	99	--------	--------	1	1	8	14
Phosphate rock (P₂O₅)	r 9,313	9,288	(2)	99	99	--------	--------	1	1	35	40
Potash (K₂O equivalent)	r 4,141	4,282	3	65	57	--------	--------	35	43	22	19
Salt, common	41,111	44,002	7	93	92	--------	--------	7	8	2	2
Sand and gravel ... million tons	r 908	918	1	100	100	--------	--------	(2)	(2)	--------	--------
Stone, crushed ... do	r 783	815	4	100	100	--------	--------	NA	NA	(2)	(2)

Sulfur, all forms	r 8,247	7,888	−4	86	83	--------	--------	14	17	27	20
Talc and allied minerals	r 852	916	6	98	98	--------	--------	2	2	8	7

r Revised. NA Not available
W Withheld to avoid disclosing individual company confidential data. Figure is not included in net and gross supply.

[1] Net supply is the sum of primary shipments, secondary production, and imports minus exports. Stockpile disposals are included in primary shipments. Gross supply is the total before subtraction of exports.

[2] Less than ½ unit.

Table 17.—Shipments, net new orders, and yearend unfilled orders for selected mineral processing industries

(Millions)

Year and month	Shipments [1]			Net new orders			Unfilled orders at end of period		
	Primary metals	Blast furnaces	All other primary metals [2]	Primary metals	Blast furnaces	All other primary metals [2]	Primary metals	Blast furnaces	All other primary metals [2]
1964	$38,832	$21,236	$17,596	$41,308	$23,303	$18,005	$6,559	$4,311	$2,248
1965	41,910	22,916	18,994	41,017	21,378	19,639	5,646	2,730	2,916
1966	45,651	23,707	21,944	46,879	24,285	22,594	6,909	3,305	3,604
1967 r	45,867	22,846	23,021	45,393	23,037	22,356	7,019	3,644	3,375
1968	50,457	24,901	25,556	49,790	24,380	25,410	6,327	3,100	3,227
1968:									
January	4,012	2,114	1,898	4,424	2,526	1,898	7,431	4,056	3,375
February	4,056	2,158	1,898	4,364	2,401	1,963	7,739	4,299	3,440
March	4,119	2,165	1,954	4,244	2,262	1,982	7,864	4,396	3,468
April	4,263	2,194	2,069	4,244	2,396	1,848	7,845	4,598	3,247
May	4,423	2,288	2,135	3,900	2,014	1,886	7,322	4,324	2,998
June	4,603	2,504	2,099	3,867	1,755	2,112	6,586	3,575	3,011
July	4,741	2,720	2,021	3,859	1,791	2,068	5,704	2,645	3,059
August	3,662	1,516	2,146	3,491	1,400	2,091	5,533	2,529	3,004
September	3,963	1,626	2,337	4,092	1,682	2,410	5,662	2,585	3,077
October	4,220	1,835	2,385	4,397	1,990	2,407	5,840	2,740	3,100
November	4,180	1,807	2,373	4,475	2,120	2,355	6,133	3,053	3,080
December	4,152	1,894	2,258	4,345	1,941	2,404	6,327	3,100	3,227

r Revised.

[1] Monthly figures are seasonally adjusted and do not add to totals.

[2] "All other primary metals" obtained by subtracting blast furnace from primary metals figures.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 45–49, No. 3, March 1965–69, pp. S–5, S–6, S–7.

Table 18.—Value of selected minerals and mineral products imported and exported by the United States in 1968, by commodity groups and commodities[1]

(Thousands)

SITC code[2]	Commodity	Exports	Imports
	Minerals, nonmetallic (crude):		
271	Fertilizers, crude	$105,921	$10,050
273	Stone, sand and gravel	16,845	18,778
274	Sulfur and unroasted iron pyrites	68,619	64,345
275	Natural abrasives (including industrial diamonds)	32,564	62,082
276	Other crude minerals	100,487	150,493
	Total	324,437	305,748
	Metals (crude and scrap):		
281	Iron ores and concentrates	70,835	453,753
282	Iron and steel scrap	200,743	13,068
283	Ores and concentrates of nonferrous base metals	107,552	467,537
284	Nonferrous metal scrap	155,457	57,856
285	Platinum and platinum-group metal ores and concentrates	4,602	3,874
286	Ores and concentrates of uranium and thorium	11	563
	Total	539,200	996,650
	Mineral energy resources and related products:		
321	Coal, coke, and briquets (including peat)	523,854	16,665
331	Petroleum, crude and partly refined	11,227	1,280,627
332	Petroleum products, except chemicals	448,794	1,034,808
341	Gas, natural and manufactured	71,680	166,819
	Total	1,055,555	2,498,920
	Chemicals:		
	Inorganic chemicals:		
513	Elements, oxides, and halogen salts	231,639	201,126
514	Other inorganic chemicals	116,621	57,335
515	Radioactive and associated materials except uranium and thorium	43,030	8,628
521	Mineral tar, crude chemicals from coal, petroleum, and natural gas	67,011	13,468
	Total	458,301	280,557
	Minerals, nonmetallic (manufactured):		
661	Lime, cement, and fabricated building materials, except glass and clay	13,745	41,936
662	Clay and refractory construction materials	49,799	40,826
663	Mineral manufactures, not elsewhere specified	68,146	21,902
	Total	131,690	104,664
	Metals (manufactured):		
671	Pig iron, spiegeleisen, sponge iron, iron and steel powder and shot, and ferroalloys	27,810	82,737
672	Ingots and other primary forms of iron and steel	76,158	42,531
673	Iron and steel bars, rods, angles, shapes, and sections	55,227	527,691
674	Universals, plates and sheets of iron or steel	150,045	965,042
675	Hoops and strips of iron or steel	26,456	36,627
676	Rails and railway track construction material of iron or steel	16,660	3,105
677	Iron and steel wire (excluding wire rod)	9,665	108,180
678	Tubes, pipes, and fittings of iron or steel	184,718	266,390
679	Iron and steel castings or forgings, unworked, n.e.s	63,438	8,814
681	Silver, platinum, and platinum-group metals	64,179	120,966
682	Copper and copper alloys	282,187	874,702
683	Nickel and nickel alloys	39,586	210,112
684	Aluminum and aluminum alloys	191,340	350,098
685	Lead and lead alloys	4,740	81,857
686	Zinc and zinc alloys	15,864	78,917
687	Tin and tin alloys	14,365	183,669
688	Uranium and thorium and their alloys	126	2
689	Miscellaneous nonferrous base metals	52,739	48,945
	Total	1,275,302	3,990,384
	Grand total	3,784,485	8,176,923

---

[1] Data in this table are for the indicated SITC numbers only and therefore may not correspond to the figures classified by commodity in the "Statistical Summary" chapter of this volume.
[2] Standard Industrial Trade Classification.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports General and Consumption. FT 135, December 1968, table 1. U.S. Exports, Commodity and Country. FT 410, December 1968, table 1.

Table 19.—Percentage distribution of exports of selected minerals and mineral fuels and related products, by area of destination, 1968

SITC code [1]	Commodity	North America [2]	South America	Europe	Asia	Africa	Oceania	Soviet bloc [3]	Undesignated area [4]
271	Fertilizers, crude	27	4	31	30	--------	7	1	(5)
273	Stone, sand and gravel	88	4	3	1	(5)	(5)	--------	4
274	Sulfur and unroasted iron pyrites	7	11	57	9	6	9	1	(5)
275	Natural abrasives, including industrial diamonds	13	3	55	22	2	4	(5)	1
276	Crude minerals, n.e.c.	34	6	40	14	1	3	(5)	2
281	Iron ore and concentrates	39	--------	1	60	--------	--------	--------	(5)
282	Iron and steel scrap	15	1	26	57	(5)	--------	1	(5)
283	Ores and concentrates of nonferrous base metal	14	7	55	20	(5)	(5)	4	(5)
284	Nonferrous metal scrap	31	1	51	16	(5)	(5)	1	(5)
286	Ores and concentrates of uranium and thorium	--------	--------	--------	--------	--------	--------	--------	100
321	Coke, coal, and briquets, including peat	32	6	28	33	--------	(5)	1	(5)
331	Petroleum, crude and partly refined	65	--------	15	20	--------	--------	--------	(5)
332	Petroleum products, except chemicals	22	10	29	30	4	4	(5)	1
341	Gas, natural and manufactured	87	3	10	(5)	(5)	(5)	--------	(5)
513	Inorganic chemical elements, oxides, and halogen salts	34	10	30	9	8	2	6	1
514	Other inorganic chemicals	33	16	23	17	3	5	1	2
515	Radioactive and associated materials	4	1	85	9	(5)	(5)	(5)	1
521	Mineral tar and crude chemicals from coal, petroleum, and natural gas	5	4	63	26	1	1	(5)	(5)
661	Lime, cement, and fabricated building materials, except glass and clay	48	3	28	11	3	1	--------	6
662	Clay and refractory construction materials	54	9	18	9	1	4	1	4
663	Mineral manufactures, n.e.s	42	8	31	10	2	3	(5)	4
671	Pig iron, sponge iron, iron or steel powders and shot, and ferroalloys	28	12	31	28	(5)	(5)	--------	1
672	Iron and steel ingots and other primary forms	27	14	27	32	(5)	(5)	--------	(5)
673	Iron and steel bars, rods, angles, shapes, and sections	56	9	8	21	2	1	--------	3
674	Iron and steel plates and sheets	25	12	14	45	1	1	1	1
675	Iron and steel hoop and strip	55	4	24	8	2	4	1	2
676	Iron and steel rails and railway track construction material	14	28	6	45	3	2	--------	2
677	Iron and steel wire (except insulated electric)	56	5	9	18	4	2	--------	6
678	Iron and steel tubes, pipes and fittings	39	13	10	15	16	4	1	2
679	Iron and steel castings and forgings (rough)	81	3	11	3	1	(5)	(5)	1
681	Silver, platinum, and platinum-group metals	24	1	63	12	(5)	(5)	--------	(5)
682	Copper and copper alloys	7	13	64	15	(5)	(5)	1	(5)
683	Nickel and nickel alloys	27	8	47	15	1	1	--------	1
684	Aluminum and aluminum alloys	36	10	26	21	3	3	(5)	1
685	Lead and lead alloys	19	20	41	13	(5)	--------	--------	7
686	Zinc and zinc alloys	25	2	6	65	(5)	(5)	--------	2
687	Tin and tin alloys	14	2	10	73	--------	--------	--------	1
688	Uranium and thorium and their alloys	12	--------	--------	79	--------	--------	--------	9
689	Base metals and alloys, n.e.c.	31	3	54	9	(5)	1	(5)	2

[1] Standard Industrial Trade Classification.
[2] Includes Trinidad and Netherlands Antilles.
[3] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Rumania, mainland China, North Korea, North Vietnam, and Yugoslavia.
[4] Special category exports.
[5] Less than ½ unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Exports Schedule B Commodity and Country. FT 410, December 1968, table 2.

Table 20.—Percentage distribution of imports of principal minerals and mineral fuels and related products, by area of origin, 1968

SITC code [1]	Commodity	North America	South America	Europe	Asia	Africa	Oceania	Soviet bloc [2]
2713000	Phosphates, crude and apatite	100	---	---	---	(3)	---	---
2732100	Gypsum	99	---	1	---	---	---	---
2743000	Sulfur	100	---	(3)	---	---	(3)	---
2752400	Natural abrasives	4	(3)	91	(3)	5	(3)	---
2762200	Graphite, natural	42	---	29	11	18	---	---
2762500	Magnesia, refractory and caustic calcined and crude magnesite	(3)	---	90	8	(3)	2	---
2763000	Salt	85	5	4	(3)	6	---	---
2764000	Asbestos	90	(3)	(3)	---	10	---	---
2765200	Mica, including scrap	2	31	1	58	8	---	---
2765420	Fluorspar	67	---	33	---	---	---	---
2769300	Barite, crude	32	16	38	---	14	---	---
2769500	Talc	14	---	65	21	(3)	---	---
2810000	Iron ore and concentrates	68	26	1	(3)	5	(3)	---
2820000	Iron and steel scrap	87	(3)	13	(3)	(3)	(3)	---
2831110	Copper ores and concentrates	21	18	(3)	59	(3)	2	---
2833000	Bauxite	74	26	(3)	---	(3)	---	---
2834000	Lead ores and concentrates	42	39	6	(3)	1	12	---
2835000	Zinc ores and concentrates	83	12	1	---	4	(3)	---
2836000	Tin ores and concentrates	---	97	---	---	(3)	3	---
2837000	Manganese ores and concentrates	7	28	(3)	4	57	4	---
2839100	Chrome ore	---	---	16	17	26	---	41
2839200	Tungsten ores and concentrates	59	32	5	(3)	(3)	4	---
2839310	Tantalum, molybdenum, and vanadium ores and concentrates	1	36	7	(3)	50	6	---
2839320 2839330	Titanium ores	5	---	---	---	(3)	95	---
2839340	Zirconium ores	2	---	(3)	(3)	(3)	98	---
2839910	Antimony ores and needles	12	28	1	---	59	---	---
2839920	Beryllium ores and concentrates	---	59	2	---	34	5	---
2839930	Columbium ores and concentrates	6	47	3	4	40	---	---
2840200	Copper waste and scrap	86	8	3	3	---	---	---
2840300	Nickel waste and scrap	67	---	31	(3)	1	1	---
2840400	Aluminum waste and scrap	73	3	24	---	---	(3)	(3)
2840500	Magnesium waste and scrap	66	(3)	31	(3)	2	1	---
2840600	Lead waste and scrap	98	(3)	---	---	---	2	---
2840700	Zinc waste and scrap	100	---	---	---	---	---	---
2840900	Tin waste and scrap	40	34	---	1	---	25	---
2850000	Platinum-group metals, ores, concentrates, and waste	33	3	26	3	6	29	---
2860000	Thorium ores and concentrates	---	---	1	33	(3)	66	---
3214000 3218000 3219000	Coal, coke, and briquets	93	---	7	(3)	---	(3)	---
3310000	Petroleum, crude and partly refined	39	36	(3)	16	9	---	---
3320000	Petroleum products, except chemicals	48	42	9	1	(3)	(3)	(3)
3410000	Gases, natural and manufactured	100	(3)	(3)	(3)	(3)	---	---
5132500	Mercury, including waste and scrap	33	5	62	---	---	---	---
5136500	Alumina	11	37	1	1	---	50	---
5210000	Mineral tar and crude chemicals from coal, petroleum, and natural gas	15	---	81	(3)	---	1	3
5613000	Potassic fertilizers and fertilizer materials	87	(3)	11	2	---	---	---

[1] Standard International Trade Classification.
[2] U.S.S.R., Bulgaria, East Germany, Albania, Czechoslovakia, Hungary, Poland, Rumania, mainland China, North Korea, North Vietnam, and Yugoslavia.
[3] Less than ½ unit.

Source: U.S. Department of Commerce, Bureau of the Census. U.S. Imports for Consumption. FT 135, December 1968, table 2.

Table 21.—Index of stocks of crude minerals at mines or in hands of primary producers at yearend

(1957–59 = 100)

Yearend	Metals and non-metals [1]	Metals: Total	Metals: Iron ore	Metals: Other ferrous	Metals: Non-ferrous	Non-metals [1]
1964	113	133	153	44	147	104
1965	110	149	180	41	128	92
1966	107	148	172	34	172	88
1967	[r] 109	[r] 167	[r] 184	96	177	78
1968	127	201	227	110	178	93

[r] Revised.
[1] Excludes fuels.

Table 22.—Index of stocks of mineral manufacturers, consumers, and dealers at yearend

(1957–59 = 100)

Yearend	Metals and non-metals [1]	Metals: Total	Metals: Iron	Metals: Other ferrous	Metals: Base non-ferrous	Metals: Other non-ferrous	Non-metals [1]
1964	90	88	85	72	88	97	130
1965	90	89	84	72	92	99	116
1966	100	99	90	81	106	106	133
1967	100	98	89	103	95	[r] 130	138
1968	98	97	85	106	103	103	140

[r] Revised.
[1] Excludes fuels.

Table 23.—Physical stocks of mineral energy resources and related products at yearend

(Producers' stocks, unless otherwise indicated)

Fuels	1964	1965	1966	1967	1968 [p]
Coal and related products: [1]					
Bituminous and lignite [2] short tons	77,939,559	79,739,516	76,808,024	95,408,000	84,303,000
Coke do	1,971,892	2,702,946	3,078,768	5,467,532	5,985,025
Petroleum and related products:					
Carbon black thousand pounds	231,171	237,704	233,145	264,247	249,240
Crude petroleum and petroleum products thousand barrels	839,235	836,344	881,105	944,111	999,572
Crude petroleum do	230,057	220,289	238,391	248,970	272,193
Natural gas liquids do	35,679	35,867	40,423	(3)	(3)
Natural gasoline, plant condensate, and isopentane thousand barrels	(4)	(4)	(4)	5,782	5,466
Gasoline do	193,633	183,058	194,177	207,980	211,526
Special naphthas do	5,879	6,209	5,583	5,748	5,829
Liquefied gases do	(4)	(4)	(4)	64,165	76,160
Distillate fuel oil do	155,846	155,407	158,076	159,703	173,158
Residual fuel oil do	40,403	56,214	63,856	65,597	67,359
Petroleum asphalt do	14,231	16,178	17,309	19,939	20,055
Other products do	163,507	163,122	163,290	166,227	167,826
Natural gas [5] billion cubic feet	2,313	2,458	2,506	2,648	2,746

[p] Preliminary.
[1] Series on anthracite stocks in ground storage has been discontinued.
[2] Stocks at industrial, consumer, and retail yards and on upper lake locks.
[3] Now distributed among petroleum products shown below.
[4] Prior to 1967, included in natural gas liquids.
[5] American Gas Association.

Table 24.—Seasonally adjusted book value of product inventories for selected mineral processing industries

(Millions)

End of year or month		Petroleum and coal products	Stone, clay and glass products	Primary metals		
				Blast furnace and steel mills	Other primary metals [1]	Total
1964:	December	$1,745	$1,587	$3,707	$2,404	$6,111
1965:	December	1,756	1,626	3,678	2,671	6,349
1966:	December	1,869	1,746	4,043	3,066	7,109
1967:	December r	1,971	1,952	4,319	3,325	7,644
1968:						
	December	2,118	2,219	4,039	3,513	7,552
	January	1,978	1,952	4,306	3,354	7,660
	February	1,956	1,949	4,318	3,356	7,674
	March	1,970	1,930	4,322	3,393	7,715
	April	1,955	1,927	4,341	3,383	7,724
	May	1,981	1,940	4,302	3,355	7,657
	June	2,021	1,957	4,109	3,397	7,506
	July	2,047	1,997	3,831	3,424	7,255
	August	2,066	2,003	3,994	3,439	7,433
	September	2,083	2,029	4,065	3,437	7,502
	October	2,114	2,064	3,985	3,441	7,426
	November	2,136	2,153	4,010	3,494	7,504

r Revised.

[1] "Other primary metals" obtained by subtracting blast furnace from primary metals figures.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 45–49, No. 3, March 1965–69, pp. S–5 to S–6.

Table 25.—Total employment in selected mineral industries

(Thousands)

	1964	1965	1966	1967	1968
MINING					
Metal:					
Iron	24.6	25.9	26.3	27.5	25.7
Copper	27.1	30.0	31.7	23.8	30.3
Total [1]	79.5	83.8	86.5	79.1	84.2
Nonmetal mining and quarrying	116.2	119.6	120.8	120.9	121.8
Fuels:					
Bituminous	136.1	131.8	129.9	135.0	132.9
Other coal	11.2	9.6	7.8	7.0	6.2
Crude petroleum and natural gas fields	160.4	156.6	152.4	149.8	148.1
Oil and gas field services	130.7	130.5	127.4	120.7	131.7
Total	438.4	428.5	417.5	412.5	418.9
Total mining	634.1	631.9	624.8	612.5	624.9
MANUFACTURING					
Minerals:					
Fertilizers, complete and mixing only	38.0	39.7	40.7	40.6	39.1
Cement, hydraulic	38.6	38.0	38.0	36.5	35.6
Blast furnaces, steelworks, and rolling mills	556.7	580.2	571.3	553.1	553.4
Nonferrous smelting and refining	69.7	73.9	78.1	75.5	79.7
Total	703.0	731.8	728.1	705.7	707.8
Fuels:					
Petroleum refining	149.6	148.1	149.6	152.8	150.5
Other petroleum and coal products	34.2	34.8	36.4	36.6	36.2
Total [2]	183.8	182.9	186.0	189.4	186.7
Total manufacturing	886.8	914.7	914.1	895.1	894.5

[1] Includes other metal mining not shown separately.

[2] Standard Industrial Classification 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings Statistics for the United States 1909–67. Bull. 1312–5, October 1967, 851 pp. Employment and Earnings. V. 15, No. 9, March 1969, table B–2.

Table 26.—Average hours and gross earnings of production and related workers in the mineral and mineral fuels industries

	1964	1965	1966	1967	1968
MINING					
Metal:					
Iron ores:					
Weekly earnings	$125.83	$129.24	$138.09	$138.60	$144.70
Weekly hours	40.2	40.9	42.1	42.0	41.7
Hourly earnings	$3.13	$3.16	$3.28	$3.30	$3.47
Copper ores:					
Weekly earnings	$130.42	$136.71	$140.07	$140.51	$162.37
Weekly hours	42.9	43.4	43.5	43.1	47.2
Hourly earnings	$3.04	$3.15	$3.22	$3.26	$3.44
Total:[1]					
Weekly earnings	$122.54	$127.30	$133.77	$136.83	$148.77
Weekly hours	41.4	41.6	42.2	42.1	43.5
Hourly earnings	$2.96	$3.06	$3.17	$3.25	$3.42
Nonmetallic mining and quarrying:					
Weekly earnings	$111.85	$117.45	$123.39	$128.65	$136.35
Weekly hours	45.1	45.7	45.7	45.3	45.0
Hourly earnings	$2.48	$2.57	$2.70	$2.84	$3.03
Fuels:					
Total coal mining:					
Weekly earnings	$126.88	$137.51	$145.95	$150.93	$151.59
Weekly hours [2]	39.0	39.9	40.3	40.5	39.7
Hourly earnings [2]	$3.26	$3.46	$3.62	$3.72	$3.80
Bituminous coal:					
Weekly earnings	$128.91	$140.26	$148.44	$153.09	$153.16
Weekly hours [2]	39.2	40.2	40.6	40.7	39.8
Hourly earnings [2]	$3.30	$3.49	$3.65	$3.75	$3.83
Crude petroleum and natural gas:					
Weekly earnings	$112.63	$116.18	$122.69	[3] $130.66	$137.71
Weekly hours	42.5	42.4	42.6	42.7	42.9
Hourly earnings	$2.65	$2.74	$2.88	$3.06	$3.21
Total fuels:[4]					
Weekly earnings	$118.15	$124.29	$131.55	$138.83	$143.08
Weekly hours	41.1	41.5	41.7	41.8	41.7
Hourly earnings	$2.89	$3.01	$3.16	$3.33	$3.44
Total mining:[4]					
Weekly earnings	$116.19	$121.52	$127.73	$131.85	$141.35
Weekly hours	43.6	44.0	44.2	44.0	44.4
Hourly earnings	$2.67	$2.77	$2.90	$3.00	$3.18
MANUFACTURING					
Fertilizers, complete and mixing only:					
Weekly earnings	$93.74	$96.57	$101.38	$104.98	$108.97
Weekly hours	43.4	43.5	43.7	43.2	42.4
Hourly earnings	$2.16	$2.22	$2.32	$2.43	$2.57
Cement, hydraulic:					
Weekly earnings	$121.30	$124.42	$132.61	$133.40	$144.35
Weekly hours	41.4	41.2	41.7	41.3	41.6
Hourly earnings	$2.93	$3.02	$3.18	$3.23	$3.47
Blast furnaces, steel, and rolling mills:					
Weekly earnings	$140.15	$141.86	$145.71	$145.16	$155.86
Weekly hours	41.4	41.0	40.7	40.1	40.8
Hourly earnings	$3.41	$3.46	$3.58	$3.62	$3.82
Nonferrous smelting and refining:					
Weekly earnings	$120.22	$124.44	$129.98	$134.30	$144.08
Weekly hours	41.6	41.9	42.2	42.1	42.5
Hourly earnings	$2.89	$2.97	$3.08	$3.19	$3.39
Petroleum refining and related industries:					
Weekly earnings	$133.76	$138.42	$144.58	$152.87	$159.38
Weekly hours	41.8	42.2	42.4	42.7	42.5
Hourly earnings	$3.20	$3.28	$3.41	$3.58	$3.75
Petroleum refining:					
Weekly earnings	$139.52	$145.05	$151.56	$159.09	$166.27
Weekly hours	41.4	41.8	42.1	42.2	42.2
Hourly earnings	$3.37	$3.47	$3.60	$3.77	$3.94
Other petroleum and coal products:					
Weekly earnings	$112.49	$115.90	$120.22	$129.51	$135.91
Weekly hours	43.6	43.9	43.4	44.2	43.7
Hourly earnings	$2.58	$2.64	$2.77	$2.93	$3.11
Total manufacturing:[4]					
Weekly earnings	$134.43	$137.35	$141.83	$142.96	$153.76
Weekly hours	41.3	41.3	41.2	40.9	41.3
Hourly earnings	$3.25	$3.32	$3.44	$3.51	$3.74

[1] Includes other metal mining not shown.
[2] 11-month average.
[3] Corrected figure.
[4] Weighted average of data computed using figures for production workers as weights.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings for the United States 1909–67. Bull. 1312–5, October 1967, 852 pp. Employment and Earnings. V. 15, No. 9, March 1969, table C–2.

Table 27.—Average labor-turnover rates in selected mineral industries[1]

(Per thousand employees)

Rates and year	Manufacturing	Cement, hydraulic	Blast furnaces, steel and rolling mills	Nonferrous smelting and refining	Metal mining	Iron ore	Copper ore	Petroleum refining and related industries[2]	Petroleum refining	Coal mining
Total accession rate:										
1966	50	23	29	32	35	26	30	21	16	17
1967	44	28	25	29	35	33	28	23	17	16
1968	46	28	30	35	34	28	29	24	18	18
Total separation rate:										
1966	46	28	24	27	35	30	26	21	15	18
1967	46	31	25	27	38	35	35	22	16	18
1968	46	25	35	30	35	36	27	24	17	17
Layoff rate:										
1966	12	13	5	3	7	15	2	6	5	9
1967	14	17	9	3	9	17	5	6	5	5
1968	12	10	14	3	8	18	5	5	4	5

[1] Monthly rates are available in Employment and Earnings as indicated in source.
[2] Standard Industrial Classification Industry 295, paving and roofing materials, included in total.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Employment and Earnings Statistics for the United States, 1909–67. Bull. 1312–5, October 1967, 852 pp. Employment and Earnings. V. 15, No. 10, April 1969, table D-2.

Table 28.—Wages, salaries, and average annual earnings in the United States

	1966[r]	1967	1968[p]	Percent change	
				1966–67	1967–68
Wages and salaries:					
All industries, total ....millions..	$394,499	$423,483	$464,973	7.3	9.8
Mining ....do....	4,516	4,647	4,870	2.9	4.8
Manufacturing ....do....	128,069	134,165	145,883	4.8	8.7
Average earnings per full-time employee:					
All industries, total	5,967	6,236	6,654	4.5	6.7
Mining	7,134	7,556	7,958	5.9	5.3
Manufacturing	6,643	6,880	7,345	3.6	6.8

[p] Preliminary. [r] Revised.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 49, No. 7, July 1969.

Table 29.—Labor-productivity indexes for selected minerals

(1957–59 = 100)

Year	Copper, crude ore mined per—			Iron, crude ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1963	133.6	125.3	119.7	168.6	163.5	157.3
1964	145.0	136.7	131.1	187.5	180.8	169.1
1965	146.0	136.1	129.1	183.0	176.9	162.6
1966	149.2	138.6	131.1	186.6	183.1	163.5
1967 p	133.0	134.4	128.4	190.1	187.2	167.5
	Copper, recoverable metal mined per—			Iron, usable ore mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1963	131.3	123.0	117.5	129.3	125.4	120.6
1964	138.4	130.5	125.2	145.5	140.3	131.2
1965	135.3	126.2	119.6	r 143.2	r 138.5	r 127.3
1966	134.8	126.0	119.2	147.0	144.3	128.9
1967 p	118.3	119.6	114.2	138.8	136.7	122.3
	Petroleum, refined per—			Bituminous coal and lignite mined per—		
	Employee	Production worker	Production worker man-hour	Employee	Production worker	Production worker man-hour
1963	142.9	145.0	146.8	151.5	150.1	135.7
1964	r 153.9	r 156.9	r 154.7	162.6	161.5	144.4
1965	163.7	166.8	167.3	176.7	176.5	154.2
1966	p 177.2	p 180.9	p 180.4	187.3	188.8	162.5
1967 p	NA	NA	NA	187.3	188.4	162.5

r Revised. p Preliminary. NA Not available.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Index of Output per Man-hour Selected Industries 1939 and 1947–67. BLS Bull. 1612, December 1968, 101 pp.

Table 30.—Index of average unit mine value of minerals produced

(1957–59 = 100)

	1964	1965	1966	1967	1968
METALS					
Ferrous	110.9	112.1	112.2	116.7	118.8
Nonferrous:					
Base	112.5	123.2	124.8	128.7	137.4
Monetary	120.5	120.5	124.7	136.9	172.3
Other	98.6	99.5	92.3	r 86.2	87.0
Average	109.7	117.7	117.6	r 120.3	130.1
Average all metals	110.3	114.9	114.9	118.5	124.5
NONMETALS					
Construction	101.9	101.5	101.9	104.1	104.8
Chemical	101.2	104.5	105.6	111.1	115.4
Other	103.5	103.3	103.5	r 109.8	114.1
Average	101.9	102.1	102.6	r 105.6	107.2
FUELS					
Coal	91.4	90.8	92.0	r 93.6	95.5
Crude oil and natural gas [1]	100.8	100.4	101.1	102.6	103.6
Average	98.0	97.8	99.1	r 100.7	101.3
Grand total	99.9	100.3	101.3	r 103.3	104.2

r Revised.

[1] Does not cover isopentane, LPG, and other natural gas liquids.

Table 31.—Index of implicit unit value of minerals produced

(1957–59 = 100)

	1964	1965	1966	1967	1968 [p]
METALS					
Ferrous	112.2	113.8	114.6	119.8	121.5
Nonferrous:					
Base	113.2	123.5	124.6	129.1	137.0
Monetary	116.9	116.2	116.6	124.5	155.2
Other	97.3	97.3	91.7	84.7	78.7
Average	112.1	121.8	122.3	120.3	129.0
Average all metals	112.8	119.4	119.7	119.7	126.4
NONMETALS					
Construction	101.8	101.6	103.2	103.6	104.2
Chemical	101.6	103.0	107.0	111.1	113.7
Other	105.2	104.2	105.8	111.9	127.5
Average	101.9	102.0	104.1	105.6	107.2
FUELS					
Coal	90.9	90.6	92.1	91.1	95.8
Crude oil and natural gas	101.6	[r] 101.6	103.1	103.6	104.3
Average	98.5	98.7	100.7	101.3	102.5
Grand total	100.7	101.5	103.3	103.5	105.4

[p] Preliminary. [r] Revised.

Table 32.—Price indexes for selected metals, minerals, and fuels

(1957–59 = 100 unless otherwise stated)

Commodity	Annual average 1967	Annual average 1968	Percent change from 1967
Metals and metal products	[r] 109.6	112.4	+2.6
Iron and steel	103.6	105.5	+1.8
Iron ore	89.9	88.2	—1.9
Iron and steel scrap	72.5	67.4	—7.0
Semifinished steel products	[r] 105.1	107.3	+2.1
Finished steel products	[r] 106.0	108.6	+2.5
Foundry and forge shop products	[r] 112.1	115.0	+2.6
Pig iron and ferroalloys	80.0	80.7	+.9
Nonferrous metals	[r] 120.9	125.3	+3.6
Primary metal refinery shapes	[r] 123.6	131.8	+6.6
Aluminum ingot	99.5	101.5	+2.0
Copper, ingot, electrolytic	130.5	NA	-------
Lead, pig, common	107.8	102.0	—5.4
Zinc, slab, prime western	124.4	121.3	—2.5
Nonferrous scrap	134.8	136.6	+1.3
Nonmetallic mineral products	104.3	108.1	+3.6
Concrete ingredients	[r] 105.9	109.2	+3.1
Sand, gravel, and crushed stone	109.0	113.1	+3.8
Concrete products	[r] 105.4	108.1	+2.6
Structural clay products	[r] 110.4	113.1	+2.4
Gypsum products	[r] 102.8	105.5	+2.6
Other nonmetallic minerals	[r] 102.0	105.0	+2.9
Building lime	117.6	118.9	+1.1
Insulation materials	[r] 90.8	96.1	+5.8
Asbestos cement shingles	[r] 118.0	121.9	+3.3
Bituminous binders [1]	[r] 98.3	100.0	+1.7
Fertilizer materials	[2] 106.0	100.3	—5.4
Nitrogenates	98.2	88.5	—9.9
Phosphates	125.6	129.1	+2.8
Phosphate rock	147.4	147.4	-------
Potash	102.7	90.8	—11.6
Muriate, domestic	97.9	85.2	—13.0
Sulfate	120.9	115.0	—4.9
Fuels and related products and power	103.6	102.4	—1.2
Coal	[r] 103.3	106.7	+3.3
Anthracite	92.9	99.6	+7.2
Bituminous	[r] 104.4	107.5	+3.0
Coke	112.0	116.0	+3.6
Gas fuels [1]	[r] 133.7	123.8	—7.4
Electric power [1]	100.7	101.5	+.8
Petroleum products, refined	102.2	100.3	—1.9
Crude petroleum	98.6	99.4	+.8
All commodities other than farm and food	106.3	109.0	+2.5
All commodities	106.1	108.7	+2.5

[r] Revised. NA Not available
[1] January 1958 = 100.
[2] Corrected figure.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January 1968–February 1969, tables 2 and 2–A.

Table 33.—Comparative mineral energy resource prices

Fuel	1967	1968
Bituminous coal, average prices per net ton at merchant coke ovens	[r] $10.34	$9.54
Anthracite, average sales realization per net ton at preparation plants, excluding dredge coal:		
Chestnut	$12.03	$13.02
Pea	$9.75	$10.80
Buckwheat No. 1	$6.35	$10.13
Petroleum and petroleum products:		
Crude petroleum, average price per barrel at well	$2.92	$2.94
Gasoline, average dealers' net price (excluding taxes) of gasoline in 55 U.S. Cities [1] cents per gallon	16.31	16.51
Residual fuel oil:		
No. 6 fuel, average of high and low price per barrel (refinery) in Philadelphia [1]	$3.10	$3.10
Bunker C, average price per barrel for all Gulf ports	$1.98	$1.67
Distillate fuel oil:		
No. 2 distillate, average of high and low prices at Philadelphia [1] cents per gallon (refinery)	10.57	10.90
No. 2 distillate, average price for all Gulf ports [1] do	9.48	9.40
Natural gas:		
Average U.S. value at well cents per thousand cubic feet	16.0	16.4
Average U.S. value at point of consumption do	51.9	50.4

[r] Revised.

[1] Platt's Oil Price Handbook.

Table 34.—Cost of fuel in steam-electrical power generation

(Cents per million Btu)

Region	1965			1966			1967		
	Coal	Oil	Gas	Coal	Oil	Gas	Coal	Oil	Gas
New England	33.4	34.4	34.2	33.6	32.9	33.8	34.3	30.5	32.2
Middle Atlantic	26.2	32.3	33.8	26.5	31.8	34.4	27.8	33.2	35.4
East North-Central	24.3	66.2	25.9	24.4	59.8	25.9	24.7	62.9	26.7
West North-Central	26.2	50.8	24.2	26.4	49.9	24.2	25.6	51.6	24.0
South Atlantic	25.1	33.7	32.3	25.6	33.6	31.8	26.6	32.5	31.7
East South-Central	18.9	62.8	23.8	19.3	52.1	22.7	20.1	53.2	23.4
West South-Central	17.7	50.4	19.8	------	40.7	19.8	------	42.4	19.9
Mountain	19.3	26.2	27.1	20.4	25.4	26.7	20.1	26.1	26.2
Pacific	------	32.0	31.4	------	31.5	31.5	------	31.4	30.8
United States	24.4	33.1	25.0	24.7	32.4	25.0	25.2	32.2	24.7

Source: National Coal Association. Steam-Electric Plant Factors. 1965 through 1967, table 2.

Table 35.—Cost of electrical energy

(Cents per kilowatt-hour)

Region	1965			1966			1967		
	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial	Total	Residential	Commercial and industrial
New England	2.4	3.0	2.0	2.3	2.9	1.9	2.3	2.9	1.9
Middle Atlantic	1.9	2.7	1.6	1.9	2.7	1.5	1.8	2.6	1.5
East North-Central	1.7	2.5	1.3	1.7	2.4	1.3	1.6	2.4	1.3
West North-Central	2.0	2.6	1.7	2.0	2.5	1.7	2.0	2.5	1.7
South Atlantic	1.6	2.1	1.3	1.6	2.1	1.3	1.6	2.0	1.3
East South-Central	.9	1.4	.7	.9	1.3	.7	.9	1.3	.7
West South-Central	1.6	2.4	1.3	1.6	2.3	1.2	1.5	2.3	1.2
Mountain	1.5	2.2	1.2	1.5	2.2	1.2	1.5	2.2	1.3
Pacific	1.3	1.8	1.1	1.2	1.7	1.0	1.2	1.7	1.0
Alaska and Hawaii	2.5	2.9	2.2	2.5	2.9	2.2	2.5	2.9	2.2
United States	1.6	2.3	1.3	1.6	2.2	1.3	1.6	2.2	1.3

Source: Edison Electric Institute. Statistical Yearbook of the Electric Utilities Industry. 1965 through 1967.

Table 36.—Indexes of principal metal mining expenses[1]

(1957-59 = 100)

Year	Total	Labor	Supplies	Fuel	Electrical energy
1964	[2] 98	[2] 95	102	97	101
1965	[2] 102	[2] 101	103	99	101
1966	[2] 104	[2] 103	105	101	100
1967	109	[r] 111	107	104	101
1968 [p]	113	118	109	102	102

[p] Preliminary. [r] Revised.

[1] Indexes constructed using the following weights derived from the 1963 Census of Mineral Industries: Labor, 54.11; explosives, 2.35; steel mill shapes and forms, 6.40; all other supplies, 26.75; fuels, 4.86; electric energy, 5. 53; and data from Wholesale Prices and Price Indexes published by the U.S. Department of Labor, Bureau of Labor Statistics. The index is computed for iron and copper ores only, because sufficient data are not available for other mining sectors.

[2] Revised because of the change in weight values.

Table 37.—Index of major input expenses for bituminous coal and crude petroleum and natural gas mining[1]

(1957-59 = 100)

Year	Bituminous coal	Crude petroleum and natural gas	Year	Bituminous coal	Crude petroleum and natural gas
1964	98	99	1967 [p]	87	100
1965	86	100	1968	NA	NA
1966	86	100			

[p] Preliminary. NA Not available.

[1] Indexes constructed by using data from Wholesale Prices and Price Indexes, annual and monthly, published by the U.S. Department of Labor, Bureau of Labor Statistics, and weights derived from data shown in the 1963 Census of Mineral Industries, U.S. Department of Commerce, Bureau of the Census. Weights used are: Bituminous coal: Labor, 62.98; explosives, 1.77; steel mill shapes and forms, 3.88; all other supplies, 24.92; fuels, 1.76; electric energy, 4.69. Crude petroleum and natural gas: Labor, 46.3; fuel, 2.6; electric energy, 3.5; and all other, 47.6.

Table 38.—Indexes of relative labor costs and productivity for iron ore, copper, bituminous coal, and petroleum mining[1]

(1957-59 =100)

Year	Iron ore [2]	Copper [2]	Bituminous coal	Petroleum
	INDEX OF LABOR COSTS PER UNIT OF OUTPUT			
1964	87	101	75	98
1965	91	110	76	98
1966	94	112	75	94
1967	97	123	p 77	p 93
1968 p	98	135	NA	NA
	INDEX OF VALUE OF PRODUCT PER MAN-PERIOD			
1964	123	139	134	120
1965	119	145	140	124
1966	[3] 119	148	151	136
1967	115	146	p 163	p 147
1968 p	121	155	NA	NA
	INDEX OF LABOR COSTS PER DOLLAR OF PRODUCT			
1964	93	91	84	102
1965	97	90	85	102
1966	101	91	82	98
1967	105	93	p 79	p 95
1968 p	105	92	NA	NA

p Preliminary. NA Not available.

[1] Index of labor costs per unit of output: Iron ore and copper indexes are computed from data found in Employment and Earnings and Wholesale Price Indexes, published by the U.S. Department of Labor. Bituminous coal index based upon net tons per man per day (see chapter on bituminous coal) and index of average earnings derived from Bureau of Labor Statistics data on hourly earnings; petroleum index based on barrels per year (see chapter on petroleum) and Bureau of Employment Security data on total wages in petroleum production.

Index of value of product per man-period: Iron ore and copper indexes are computed from data found in Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on net tons per man per day and mine values of production; petroleum index based on average employment and total value of production.

Index of labor costs per dollar of product: Iron ore and copper indexes are computed from data found in Employment and Earnings and Wholesale Price Indexes. Bituminous coal index based on index of value per man per day and index of average earnings; petroleum index based on total value of production and total wages.

[2] Indexes are for recoverable metal.

[3] Corrected figure.

Table 39.—Price indexes for selected cost items in mineral and mineral fuels production

(1957-59 =100, unless otherwise specified)

Commodity	1968		Change from January (percent)	Annual average		Change from 1967 (percent)
	January	December		1967	1968	
Coal	105.0	112.7	+7.3	r 103.3	106.7	+3.3
Coke	112.0	120.3	+7.4	112.0	116.0	+3.6
Gas fuels (January 1958 =100)	130.0	120.9	−7.0	r 133.7	123.8	−7.4
Petroleum products, refined	98.8	99.0	+.2	102.2	100.3	−1.9
Industrial chemicals	98.5	97.9	−.6	97.4	98.4	+1.0
Lumber	114.0	142.2	+24.7	108.4	127.2	+17.3
Explosives	112.0	114.8	+2.5	112.4	114.2	+1.6
Construction machinery and equipment	127.2	132.7	+4.3	r 123.2	129.6	+5.2

r Revised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes, January-February 1968, tables 2 and 2B, and January 1969, tables 2 and 2A. January-December 1968 issues, table 2, used to figure annual average for explosives.

Table 40.—Price indexes for mining construction and material handling machinery and equipment

(1957-59 = 100)

Year	Construction machinery and equipment	Mining machinery and equipment	Oilfield machinery and tools	Power cranes, draglines, shovels, etc.	Specialized construction machinery	Portable air compressors	Scrapers and graders	Mixers, pavers, spreaders, etc.	Tractors other than farm
1964	112.4	110.5	104.3	111.8	108.5	117.6	110.8	116.3	114.7
1965	115.3	113.3	104.7	113.7	110.3	128.7	114.2	119.6	117.6
1966	118.9	116.8	106.2	118.3	114.5	133.8	117.1	123.7	120.8
1967	[r] 123.2	120.3	[r] 110.0	[r] 122.3	117.0	[r] 134.9	120.1	[r] 128.5	[r] 126.1
1968	129.6	124.0	116.5	127.7	123.0	131.7	125.8	134.1	133.9

[r] Revised.

Source: U.S. Department of Labor, Bureau of Labor Statistics. Wholesale Prices and Price Indexes. January 1969, table 2A, and previous years.

Table 41.—National income originated in the mineral industries

Industry	Income, millions			Change from 1967 (percent)
	1966 [r]	1967	1968 [p]	
Mining	$6,338	$6,191	$6,548	+5.8
Metal mining	1,071	633	707	+11.7
Coal mining	1,387	1,424	1,421	−.2
Crude petroleum and natural gas	2,690	2,865	3,040	+6.1
Mining and quarrying of nonmetallic metals	1,190	1,269	1,380	+8.7
Manufacturing	191,467	195,621	215,383	+10.1
Chemicals and allied products	13,756	14,159	15,561	+9.9
Petroleum refining and related industries	5,780	6,778	7,126	+5.1
Stone, clay, and glass products	5,920	5,781	6,330	+9.5
Primary metal industries	16,291	15,464	16,670	+7.8
All industries	620,585	654,011	714,395	+9.2

[p] Preliminary. [r] Revised.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 49, No. 7, July 1969.

Table 42.—Annual average profit rates on shareholders' equity, after taxes, and total dividends, selected mineral manufacturing corporations

Industry	Annual profit rate (percent)			Total dividends (millions)		
	1967	1968	Change from 1967	1967	1968	Change from 1967 (percent)
All manufacturing [1]	11.7	12.1	+0.4	$13,262	$14,189	+7.0
Primary metals	9.0	8.9	−.1	1,137	1,205	+6.0
Primary iron and steel	7.7	7.6	−.1	616	640	+3.9
Primary nonferrous metals	11.0	10.7	−.3	520	565	+8.7
Stone, clay, and glass products	8.2	9.2	+1.0	354	353	−.3
Chemicals and allied products	13.1	13.3	+.2	1,733	1,844	+6.4
Petroleum refining and related industries	12.5	12.2	−.3	2,660	2,876	+8.1
Petroleum refining	12.5	12.4	−.1	2,654	2,866	+8.0

[1] Except newspapers.

Source: Federal Trade Commission, Securities and Exchange Commission. Quarterly Financial Report for Manufacturing Corporations. 1st Quarter and 4th Quarter 1968, tables 4, 8.

Table 43.—Industrial and commercial failures and liabilities in mining and manufacturing

Industry	1966	1967	1968
Mining:[1]			
Number of failures	73	71	57
Current liabilities ...thousands	$15,740	$24,576	$28,773
Manufacturing:			
Number of failures	1,779	1,761	1,456
Current liabilities ...thousands	$337,121	$301,293	$262,927
All industrial and commercial industries:			
Number of failures	13,061	12,364	9,636
Current liabilities ...thousands	$1,385,659	$1,265,227	$940,996

[1] Including fuels.

Source: Dun & Bradstreet, Inc., Business Economics Department. Quarterly Failure Report, Detailed Divisions of Industry, Fourth Quarter 1968. January 31, 1969, 4 pp.

Table 44.—Expenditures for new plant and equipment by firms in mining and selected mineral manufacturing industries

(Billions)

Industry	1966	1967	1968
Mining [1]	$1.47	$1.42	$1.42
Manufacturing:			
Primary iron and steel	2.17	2.31	2.36
Primary nonferrous metals	.86	.90	.90
Stone, clay, and glass products	.91	.73	.71
Chemical and allied products	2.99	2.88	2.69
Petroleum and coal products	4.42	4.65	4.87
All manufacturing	26.99	26.69	26.44

[1] Including fuels.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 48, No. 6, June 1968, p. 10; v. 49, No. 6, June 1969, p. 14.

Table 45.—Plant and equipment expenditures of foreign affiliates of U.S. companies by area and industry

(Millions)

Area and country	1966			1967			1968 [1]		
	Mining and smelting	Petroleum	Manufacturing r	Mining and smelting	Petroleum	Manufacturing	Mining and smelting	Petroleum	Manufacturing
Canada	r $297	r $649	$1,174	$310	$636	$998	$401	$681	$893
Latin America	229	268	451	292	301	484	412	426	659
Europe	r 7	778	2,244	8	1,049	2,344	10	1,053	2,488
All other areas	257	r 832	714	293	1,032	687	278	1,435	924
Total [2]	r 789	r 2,526	4,583	902	3,018	4,513	1,101	3,595	4,963

r Revised.

[1] Estimated on the basis of company projections.

[2] Details may not add to total because of rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 48, No. 9, September 1968, p. 18.

Table 46.—Estimated gross proceeds of new corporate securities offered for cash in 1968[1]

Type of security	Total corporate		Manufacturing		Extractive[2]	
	Millions	Percent	Millions	Percent	Millions	Percent
Bonds	$17,383	79.1	$5,668	81.2	$205	34.6
Preferred stock	637	2.9	65	.9	------	------
Common stock	3,946	18.0	1,246	17.9	389	65.4
Total	21,966	100.0	6,979	100.0	594	100.0

[1] Substantially all new issues of securities for cash sale in the United States in amounts over $100,000 and with terms of maturity of more than 1 year are covered in these data.

[2] Including fuels.

Source: U.S. Securities and Exchange Commission. Statistical Bulletin. V. 28, No. 4, April 1969, p. 12.

Table 47.—Direct private investment of U.S. companies in foreign petroleum industries in 1967 p

(Millions; net inflows to the United States designated by −)

	Petroleum				All industries			
	Book value beginning of year	Net capital outflows	Undistributed earnings of subsidiaries	Book value end of year	Book value beginning of year	Net capital outflows	Undistributed earnings of subsidiaries	Book value end of year
Canada	$3,608	$115	$93	$3,819	$16,999	$392	$644	$18,069
Latin American Republics, all	2,897	−9	24	2,917	9,826	191	172	10,213
Other Western Hemisphere	578	−37	23	585	1,622	26	39	1,708
Europe	3,981	526	−89	4,404	16,209	1,442	266	17,882
Africa	1,104	126	14	1,232	2,074	176	44	2,277
Middle East	1,557	134	−27	1,607	1,669	150	−14	1,748
Far East	913	50	32	992	2,227	168	142	2,533
Oceania	521	50	17	591	2,069	326	117	2,515
International[1]	1,047	147	82	1,264	2,016	149	168	2,321
Total[2]	16,205	1,103	169	17,410	54,711	3,020	1,578	59,267

p Preliminary.

[1] Comprised of international trading and shipping companies.

[2] Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 48, No. 10, October 1968, pp. 24–25.

Table 48.—Direct private investments of the United States in foreign mining and smelting industries in 1967 p

(Millions)

	Value	Net capital outflow	Undistributed earnings of subsidiaries	Earnings [1]	Income [2]
Canada	$2,337	$168	$82	$240	$154
Latin America, total	1,218	—1	21	295	265
Mexico	100	—67	15	20	5
Panama	19	-------	-------	-------	-------
Brazil	68	(3)	(3)	(3)	(3)
Chile	517	17	—4	135	129
Peru	340	43	1	72	72
Europe	61	7	(4)	6	7
Africa, total	398	21	9	74	60
South Africa, Republic of	99	15	10	45	29
Far East	40	1	3	5	1
Oceania, total	322	57	14	21	9
Australia	320	55	14	20	8
All other countries [5]	434	63	2	101	100
Total, all areas [6] [7]	4,810	316	132	743	596

p Preliminary

[1] Earnings is the sum of the U.S. share in net earnings of subsidiaries and branch profits.

[2] Income is the sum of dividends, interest, and branch profits.

[3] Combined with other industries in source reference.

[4] Less than ½ unit.

[5] "All other countries" includes other Western Hemisphere, Middle East, and International.

[6] Excludes Communist countries.

[7] Data may not add to totals shown because of independent rounding.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 48, No. 10, October 1968, pp. 24–25.

Table 49.—Sources of funds of direct foreign investment by U.S. mining and smelting industries

(Millions)

Area	Net income			Funds from United States			Funds obtained abroad [1]			Depreciation and depletion			Total sources		
	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965
Canada	$187	$308	$320	$—24	$14	$32	$70	$66	$90	$114	$116	$122	$347	$504	$564
Latin America	234	278	301	14	—72	—31	15	33	22	101	98	107	364	337	399
Europe	4	3	7	7	2	1	—1	(2)	6	2	5	5	12	10	19
Other areas	68	71	110	44	32	122	18	89	158	22	50	44	152	242	434
Total	493	660	738	41	—24	124	102	188	276	239	269	278	875	1,093	1,416

[1] Includes miscellaneous sources.

[2] Less than ½ unit.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business.V. 47, No. 1, January 1967, p. 28.

Table 50.—Uses of funds for direct foreign investment by U.S. mining and smelting industries

(Millions)

Area	Property, plant, and equipment			Inventories			Receivables			Other assets [1]			Income paid out			Total uses		
	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965	1963	1964	1965
Canada	$195	$220	$265	$—12	$—15	$54	$19	$39	$24	$60	$96	$57	$85	$164	$164	$347	$504	$564
Latin America	109	123	160	5	9	30	10	11	12	16	24	22	224	170	175	364	337	399
Europe	5	3	5	—1	1	3	1	2	2	(2)	(2)	1	7	4	8	12	10	19
Other areas	89	117	252	5	18	13	15	21	15	5	36	64	38	50	90	152	242	434
Total	398	463	682	—3	13	100	45	73	53	81	156	144	354	388	437	875	1,093	1,416

[1] Includes miscellaneous uses.
[2] Less than ½ unit.

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 47, No. 1, January 1967, p. 28.

Table 51.—Value of foreign direct investments in the United States

(Millions)

Industry	1963	1964	1965	1966	1967 p
Total	$7,944	$8,363	$8,797	$9,054	$9,923
Petroleum	1,513	1,612	1,710	1,740	1,885

p Preliminary

Source: U.S. Department of Commerce, Office of Business Economics. Survey of Current Business. V. 48, No. 10, October 1968, p. 30.

LIBRARY
UNIVERSITY OF ILLINOIS
AT URBANA-CHAMPAIGN

Table 52.—Rail and water transportation of selected minerals and mineral energy products in the United States

(Thousand short tons)

Products	Rail [1]			Water [2]		
	1966	1967	Change from 1966 (percent)	1966	1967	Change from 1966 (percent)
Metals and minerals except fuels:						
Iron ore and concentrates	107,335	92,784	—13.6	72,364	68,291	—5.6
Iron and steel scrap	27,396	25,469	—7.0	1,499	1,551	+3.5
Pig iron	4,095	3,727	—9.0	880	698	—20.7
Iron and steel ingot, plate, bars, rods, tubing, and other primary products	53,671	49,841	—7.1	7,800	7,738	—.8
Bauxite and other aluminum ores and concentrates	4,490	4,322	—3.7	825	907	+9.9
Other nonferrous ores and concentrates	17,221	11,867	—31.1	1,541	1,378	—10.6
Nonferrous metals and alloys	9,920	9,182	—7.4	870	686	—21.1
Nonferrous metal scrap	2,368	3,035	+28.2	47	36	—23.4
Slag	2,295	1,943	—15.3	639	519	—18.8
Sand and gravel	60,002	57,544	—4.1	58,670	66,136	—5.6
Stone, crushed and broken	65,217	63,279	—3.0	11,384		
Limestone flux and calcareous stone	---------	---------	---------	34,463	31,743	—7.9
Cement, building	26,383	25,135	—4.7	9,124	8,719	—4.4
Phosphate rock	31,601	34,015	+7.6	4,144	4,738	+14.3
Clays, ceramic and refractory materials	3,648	3,249	—10.9	2,257	2,180	—3.4
Sulfur, dry	3,511	3,514	+.1	488	157	—67.8
Sulfur, liquid				7,939	8,747	+10.2
Gypsum and plaster rock	707	672	—5.0	907	787	—13.2
Other nonmetallic minerals except fuels	5,474	5,691	+4.0	4,393	6,194	+41.0
Fertilizer and fertilizer materials	15,289	18,790	+22.9	3,018	2,933	—2.8
Total	440,623	414,059	—6.0	223,252	214,138	—4.1
Mineral energy resources and related products:						
Coal:						
Anthracite	8,815	7,879	—10.6	181	---------	+1.4
Bituminous and lignite	367,506	376,704	+2.5	161,894	164,378	
Coke	382	293	—23.3	528	485	—8.1
Crude petroleum	631	660	+4.6	92,851	103,301	+11.3
Gasoline	3,458	3,257	—5.8	86,443	83,653	—3.2
Jet fuel				10,784	12,152	+12.7
Kerosine	291	260	—10.7	7,971	8,413	+5.5
Distillate fuel oil	1,910	1,777	—7.0	72,399	79,585	+9.9
Residual fuel oil	4,041	4,181	+3.5	43,323	44,032	+1.6
Asphalt, tar, and pitches	3,205	2,917	—9.0	7,202	7,566	+5.1
Liquefied petroleum gases and coal gases	5,774	6,395	+10.8	1,029	730	—29.1
Other petroleum and coal products [3]	9,515	9,218	—3.1	[r] 10,874	10,385	—4.5
Total	405,528	413,541	+2.0	495,479	514,680	+3.9
Total mineral products	846,151	827,600	—2.2	718,731	728,818	+1.4
Grand total, all commodities	1,447,852	1,406,668	—2.8	862,725	870,634	+.9
Mineral products, percent of grand total:						
Metals and minerals, except fuels	30.4	29.4	—3.3	25.9	24.6	—5.0
Mineral energy resources and related products	28.0	29.4	+5.0	57.4	59.1	+3.0
Total mineral products	58.4	58.8	+.7	83.3	83.7	+.5

[r] Revised.

[1] Revenue freight originated on respondent's road and terminated on line by originating carrier or delivered to connecting rail carrier.

[2] Domestic traffic—includes all commercial movements between points in the United States, Puerto Rico, and the Virgin Islands.

[3] Includes lubricants, naphtha and other petroleum solvents, and miscellaneous petroleum and coal products.

Sources: Interstate Commerce Commission, Bureau of Accounts. Freight Commodity Statistics, Class I Railroads in the United States for the Years Ended December 31, 1966 and 1967. Statements 68100 and 69100. Department of the Army, Corps of Engineers. Waterborne Commerce of the United States, Part 5, Nationa Summaries. Calendar Years 1966 and 1967, table 2.

Table 53.—Percentage distribution of mine shipments of bituminous coal and lignite by method of shipment and mine use

Year	Shipped by rail and trucked to rail	Shipped by water and trucked to water	Trucked to final destination	Used at mines [1]	Total production
1963	72.8	11.0	13.3	2.9	100.0
1964	71.7	12.2	13.5	2.6	100.0
1965	72.6	11.8	13.3	2.3	100.0
1966	72.5	11.6	12.6	3.3	100.0
1967	73.2	12.1	11.2	3.5	100.0

[1] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

Table 54.—Miles of utility gas main, by type of gas and by type of main[1]

Type of gas and type of main	1963	1964	1965	1966	1967
All types:					
Field and gathering	60,720	61,010	[r] 61,760	[r] 62,980	63,710
Transmission	200,940	205,400	[r] 211,240	[r] 216,980	225,360
Distribution	448,280	469,810	494,520	519,610	539,200
Total	709,940	736,220	[r] 767,520	[r] 799,570	828,270
Natural gas:					
Field and gathering	60,720	61,010	[r] 61,760	[r] 62,980	63,710
Transmission	200,020	204,730	[r] 210,660	[r] 216,410	224,790
Distribution	433,620	458,770	484,260	509,840	529,340
Total	694,360	724,510	[r] 756,680	[r] 789,230	817,840
Manufactured gas:					
Transmission	(2)	(2)	10	---------	---------
Distribution	1,490	1,460	1,420	1,180	1,140
Total	1,490	1,460	1,430	1,180	1,140
Mixed gas:					
Transmission	920	670	570	570	570
Distribution	11,890	8,310	7,810	7,800	7,950
Total	12,810	8,980	8,380	8,370	8,520
Liquefied petroleum gas:					
Distribution	1,280	1,270	1,030	790	770

[r] Revised.
[1] Excludes service pipe. Data not adjusted to common diameter equivalent. Mileage shown as of end of each year
[2] Less than 5 miles.

Source: American Gas Association. Gas Facts, a Statistical Record of the Gas Utility Industry in 1967, p. 59. For earlier years, see Historical Statistics of the Gas Industry.

Table 55.—Petroleum pipelines, selected years

(Miles)

Year	Trunklines		Gathering lines	Total
	Crude	Products		
1956	78,594	36,420	73,526	188,540
1959	70,317	44,483	75,182	189,982
1962	70,355	53,200	76,988	200,543
1965	72,383	61,443	77,041	210,867
1968	70,825	64,529	74,124	209,478

Table 56.—Research and development activity

(Millions)

	Total		Company		Federal Government	
	1966	1967 [p]	1966	1967 [p]	1966	1967 [p]
Petroleum refining and extraction	$430	$469	$383	$431	$47	$38
Percent of all industries	2.7	2.9	5.3	5.4	0.6	0.5
Chemicals and allied products	$1,461	$1,565	$1,271	$1,353	$190	$212
Percent of all industries	9.4	9.5	17.6	16.8	2.3	2.5
All industries	$15,548	$16,420	$7,216	$8,032	$8,332	$8,388

[p] Preliminary.

Source: National Science Foundation. Reviews of Data on Science Resources No. 12, January 1969, table 1.

Table 57.—Federal obligated funds for metallurgy and material research

(Thousands)

	Fiscal year 1968 [e]			Fiscal year 1969 [e]		
Federal agency	Basic research	Applied research	Total research	Basic research	Applied research	Total research
Department of Defense	$11,957	$35,169	$47,126	$19,185	$48,803	$67,988
Atomic Energy Commission	11,366	14,197	25,563	11,991	15,514	27,505
National Aeronautics and Space Administration	13,421	7,037	20,458	14,840	8,331	23,171
Bureau of Mines	----------	7,783	7,783	----------	7,924	7,924
National Science Foundation	5,497	----------	5,497	5,436	----------	5,436
Department of Agriculture	374	1,639	2,013	422	1,706	2,128
Department of Commerce	797	832	1,629	813	950	1,763
Other	1,441	1,179	2,620	1,525	1,428	2,953
Total	44,853	67,836	112,689	54,212	84,656	138,868

[e] Estimate.

Source: National Science Foundation. Federal Funds for Research, Development, and other Scientific Activities. NSF 68-27, v. 17, August 1968, pp. 144–145, 163–164, 188–189.

Table 58.—Bureau of Mines obligations for mining and mineral research and development

(Thousands)

Fiscal year	Applied research	Basic research	Development	Total
1965	$19,733	$4,355	$3,118	$27,206
1966	20,836	4,636	3,390	28,862
1967	23,148	4,841	4,423	32,412
1968	24,215	4,893	5,136	34,244
1969 [e]	26,622	4,160	5,051	35,833

[e] Estimate.

Table 59.—Bureau of Mines obligations for total research, by field of science

(Thousands)

	Fiscal year		
	1967	1968	1969 [e]
Engineering sciences	$19,043	$20,032	$20,128
Physical sciences	6,864	6,999	8,386
Mathematical sciences	597	595	705
Environmental sciences	1,485	1,482	1,563
Total	27,989	29,108	30,782

[e] Estimate.

Table 60.—Summary of government inventories of strategic and critical materials, December 31, 1968

	Acquisition cost	Market value [1]
Total inventories:		
National stockpile	$4,471,408,600	$4,875,947,700
Supplemental stockpile	1,455,203,300	1,423,202,400
Defense Production Act	958,449,900	579,024,600
Commodity Credit Corporation	1,670,300	1,994,400
Total	6,886,732,100	6,880,169,100
On order	85,356,800	93,852,100
Inventories within objective: Total on hand	3,312,118,400	3,608,694,700
Inventories excess to objective: Total on hand	3,574,613,700	3,271,474,400

[1] Market values are computed from prices at which similar materials are being traded currently; or in the absence of current trading, an estimate of the price which would prevail in commercial markets. The market values are generally unadjusted for normal premiums and discounts relating to contained qualities. The market values do not necessarily reflect the amount that would be realized at time of sale.

Source: Executive Office of the President, Office of Emergency Planning. Stockpile Report to the Congress. July–December 1968, p. 2.

Table 61.—U.S. Government stockpile disposal of mineral commodities, 1968

Commodity	Sales commitments	
	Quantity	Sales value
NATIONAL AND SUPPLEMENTAL STOCKPILE INVENTORIES		
Aluminum ... short tons	44,437	$22,628,406
Aluminum oxide ... do	310	35,495
Antimony ... do	240	185,625
Asbestos, amosite ... do	1,250	218,700
Asbestos, crocidolite ... do	190	36,100
Bauxite, refractory ... long calcined tons	916	38,472
Beryl ... short tons	2,968	1,728,238
Bismuth ... pounds	322,000	1,288,000
Cadmium ... do	876,000	2,217,467
Celestite ... short tons	2,749	43,533
Chromite, metallurgical ... short dry tons	154,597	3,514,132
Fluorspar, acid-grade ... do	1,977	25,639
Graphite, Malagasy ... short tons	75	8,625
Graphite, other than Ceylon and Malagasy ... do	1,053	136,118
Lead ... do	26,950	7,341,021
Magnesium ... do	3,502	2,197,200
Manganese, battery-grade ... short dry tons	1,000	320,000
Manganese, metallurgical ... do	381,633	7,488,761
Mica ... pounds	486,534	254,749
Molybdenum ... do	1,317,588	2,106,159
Platinum-group metals: Ruthenium ... troy ounces	12,000	509,216
Quartz crystals ... pounds	138,171	836,486
Rare earths ... short dry tons	1,266	498,408
Talc ... short tons	10	1,600
Tin ... long tons	3,508	11,390,094
Zinc ... short tons	24,875	[1] 6,765,976
Total	----------	71,814,215
DEFENSE PRODUCTION ACT (DPA) INVENTORY		
Aluminum ... short tons	13,476	6,944,449
Asbestos, chrysotile ... do	1,187	189,854
Cobalt ... pounds	4,878,798	8,335,048
Columbium ... do	1,314,132	1,686,092
Fluorspar, acid-grade ... short dry tons	9,615	389,362
Manganese, battery, synthetic dioxide ... do	150	78,500
Manganese, metallurgical ... do	7,394	107,780
Mica ... pounds	7,788	32,507
Mica, muscovite block ... do	16,820	33,519
Tungsten ... do	3,170,542	8,030,033
Total	----------	25,822,144
OTHER		
Bauxite ... long dry tons	110,000	500,000
Lithium ... pounds	6,875	1,375
Mercury ... flasks	20,668	11,068,798
Silver (fine)[2] ... troy ounces	----------	76,091,057
Total	----------	87,661,230
Grand total	----------	185,297,589

[1] Includes AID sales of 16,135 short tons.

[2] Represents that portion of the total proceeds in excess of the U.S. monetary value based on $1.2929 per ounce. 54,562,979 ounces of silver was sold at an average price of $2.0427, and 50,822,630 ounces was sold at an average price of $1.9851.

Source: Executive Office of the President, Office of Emergency Planning. Stockpile Report to the Congress. January–June, 1968, pp. 12–13; July–December 1968, pp. 13–14.

Table 62.—United Nations indexes of world[1] mineral industry production

(1963 = 100)

Industry sector and geographic area	1965	1966	1967	1968	1968 by quarters			
					1st	2nd	3rd	4th
EXTRACTIVE INDUSTRIES								
Metals:								
Non-Communist world	112	115	115	120	109	123	124	122
Industrialized countries [2]	111	115	113	121	107	126	126	124
United States and Canada	114	119	115	122	98	132	133	124
Europe	107	105	107	117	115	118	111	125
European Economic Community [3]	100	97	92	96	99	93	92	98
Less industrialized countries [4]	114	115	117	118	113	117	121	120
Latin America [5]	111	118	119	120	118	119	121	121
Asia, East and Southeast [6]	113	115	119	119	110	119	127	118
Communist Europe [7]	123	135	149	162	167	162	162	160
World	114	119	122	129	122	131	132	131
Coal:								
Non-Communist world	101	98	94	93	96	92	89	92
Industrialized countries [2]	100	97	93	91	95	91	87	92
United States and Canada	111	114	117	114	115	118	116	108
Europe	97	91	85	82	87	81	76	85
European Economic Community [3]	97	91	83	80	86	76	77	83
Less industrialized countries [4]	105	109	111	113	112	112	110	118
Latin America [5]	101	106	115	NA	NA	NA	NA	NA
Asia, East and Southeast [6]	106	110	112	113	112	112	109	120
Communist Europe [7]	106	108	111	115	117	114	112	116
World	103	102	101	101	104	101	98	102
Crude petroleum and natural gas:								
Non-Communist world	112	120	128	136	134	135	138	140
Industrialized nations [2]	105	111	116	120	122	119	119	121
United States and Canada	105	110	116	119	121	118	118	119
Europe	115	119	124	133	134	125	128	142
European Economic Community [3]	114	117	122	133	135	125	129	143
Less industrialized countries [4]	121	133	143	159	150	156	163	167
Latin America [5]	107	107	114	118	118	117	119	117
Asia, East and Southeast [6]	119	132	141	156	148	153	161	163
Communist Europe [7]	121	133	145	156	158	156	155	154
World	114	123	131	140	139	139	141	143
Total extractive industry:								
Non-Communist world	110	115	118	125	121	124	125	128
Industrialized countries [2]	106	109	111	115	113	115	115	117
United States and Canada	108	113	117	120	117	122	122	120
Europe	104	101	99	103	104	100	99	109
European Economic Community [3]	104	102	99	105	108	98	103	111
Less industrialized countries [4]	119	128	135	147	139	146	150	153
Latin America [5]	108	110	115	118	117	117	119	118
Asia, East and Southeast [6]	118	128	136	149	141	148	153	155
Communist Europe [7]	115	123	132	140	143	141	139	138
World	112	117	122	129	127	129	129	131
PROCESSING INDUSTRIES								
Base metals:								
Non-Communist world	120	124	123	132	133	137	126	134
Industrialized countries [2]	121	124	123	132	134	137	124	133
United States and Canada	121	126	117	122	128	135	110	115
Europe	119	117	118	131	130	128	127	141
European Economic Community [3]	117	116	119	133	132	128	131	144
Less industrialized countries [4]	117	125	125	138	127	133	143	147
Latin America [5]	120	124	125	140	128	133	148	152
Asia, East and Southeast [6]	113	126	128	137	131	133	139	145
Communist Europe [7]	117	127	136	145	148	146	144	144
World	119	125	127	136	138	139	131	137
Nonmetallic mineral products:								
Non-Communist world	116	121	123	131	115	134	138	137
Industrialized countries [2]	116	120	122	130	113	133	137	136
United States and Canada	114	120	118	124	106	127	134	129
Europe	116	119	121	129	111	133	136	135
European Economic Community [3]	112	115	116	125	104	129	136	132
Less industrialized countries [4]	118	125	133	141	133	143	142	148
Latin America [5]	115	124	132	142	134	143	144	148
Asia, East and Southeast [6]	120	124	135	141	134	142	139	149
Communist Europe [7]	119	131	143	154	159	155	152	152
World	117	125	131	140	132	142	143	143

See footnotes at end of table.

Table 62.—United Nations indexes of world[1] mineral industry production—Continued

(1963 = 100)

Industry sector and geographic area	1965	1966	1967	1968	1968 by quarters			
					1st	2nd	3rd	4th
PROCESSING INDUSTRIES—Continued								
Chemicals, petroleum and coal products:								
Non-Communist world	119	130	139	153	148	152	153	161
Industrialized countries [2]	119	131	140	154	149	153	154	162
United States and Canada	115	127	133	144	139	144	144	149
Europe	123	135	145	163	159	159	161	174
European Economic Community [3]	125	138	149	170	165	163	169	183
Less industrialized countries [4]	116	125	131	146	136	146	150	152
Latin America [5]	116	125	131	149	NA	NA	NA	NA
Asia, East and Southeast [6]	118	122	130	145	134	142	149	153
Communist Europe [7]	128	143	161	180	177	181	181	179
World	120	133	143	159	154	158	159	165
Overall industrial production:								
Non-Communist world	115	123	126	135	131	134	132	142
Industrialized countries [2]	115	123	126	134	131	133	131	141
United States and Canada	116	126	127	133	130	134	132	136
Europe	112	117	118	127	124	124	120	138
European Economic Community [3]	111	116	117	127	123	122	122	141
Less industrialized countries [4]	118	125	130	140	134	139	141	145
Latin America [5]	114	120	125	133	NA	NA	NA	NA
Asia, East and Southeast [6]	120	127	133	144	139	140	146	150
Communist Europe [7]	116	127	139	151	153	152	150	148
World	116	124	130	139	137	139	137	143

NA Not available.

[1] Excludes a number of countries of the Near East and Africa as well as mainland China, North Korea, and North Vietnam.

[2] All countries having a per-capita value added in manufacturing in 1958 equivalent to US$125 or more.

[3] Belgium, France, West Germany, Italy, Luxembourg, and the Netherlands.

[4] Countries having a per-capita value added in manufacturing in 1958 of less than US$125.

[5] Central and South America and the Caribbean Islands.

[6] Afghanistan, Brunei, Burma, Ceylon, Hong Kong, India, Indonesia, Iran, South Korea, Malaysia (excluding Sabah), Mongolia, Pakistan, Philippines, Singapore, Taiwan, Thailand, and South Vietnam.

[7] Albania, Bulgaria, Czechoslovakia, East Germany, Hungary, Poland, Rumania, and U.S.S.R.

Source: United Nations Monthly Bulletin of Statistics. August 1969, pp. x-xxi.

Table 63.—Comparisons of world and U.S. production and U.S. imports of principal minerals and mineral fuels in 1968

Mineral	World production (thousand short tons unless otherwise stated) p	U.S. production (percentage of world total)	U.S. imports (percentage of world production)	Total U.S. production and imports (percentage of world total 1968)	Total U.S. production and imports (percentage of world total 1967) r
METALLIC ORES AND CONCENTRATES					
Bauxite............thousand long tons..	42,880	3.9	25.6	29.5	30
Chromite..............................	5,206	....	9.6	9.6	12
Copper (content of ore and concentrate).	5,893	20.4	5.9	26.3	23
Iron ore...........thousand long tons..	670,943	12.8	6.5	19.3	21
Lead (content of ore and concentrate)..	3,309	10.8	2.6	13.4	14
Mercury....thousand 76-pound flasks..	255	11.4	9.4	20.8	21
Molybdenum (content of ore and concentrate)................short tons..	62,837	74.4	(1)	74.4	71
Nickel (content of ore and concentrate).	529	3.2	22.1	25.3	28
Platinum group (Pt, Pd, etc.) thousand troy ounces..	3,415	(1)	52.0	52.0	42
Silver...............................do....	272,657	12.0	25.9	37.9	34
Titanium concentrates:					
Ilmenite [2].........................	3,216	29.9	7.6	37.5	36
Rutile [2]..........................	357	W	4.9	W	53
Tungsten concentrate (60-percent tungsten dioxide)........short tons..	34,907	14.0	2.5	17.0	17
Zinc (content of ore and concentrate)...	5,436	9.7	8.3	18.0	18
METALS, SMELTER BASIS					
Aluminum..............................	8,864	36.7	8.9	45.6	46
Copper................................	6,649	18.6	6.1	24.7	20
Iron, pig.............................	391,000	22.7	0.2	22.9	22
Lead..................................	3,221	14.5	10.6	25.1	25
Magnesium...............short tons..	207,089	47.5	2.0	49.5	52
Steel ingots and castings..............	565,000	23.2	3.2	26.4	26
Tin..............thousand long tons..	230	1.3	24.8	26.1	24
Uranium oxide (U_3O_8) [4]....short tons..	NA	NA	NA	NA	49
Zinc..................................	5,017	22.0	6.3	28.3	27
NONMETALS					
Asbestos..............................	NA	NA	NA	NA	25
Cement [3]...........thousand barrels..	2,872,929	14.0	0.3	14.3	14
Diamond............thousand carets..	NA	NA	NA	NA	50
Feldspar..........thousand long tons..	NA	NA	NA	NA	45
Fluorspar.............................	NA	NA	NA	NA	50
Gypsum................................	NA	NA	NA	NA	63
Mica (including scrap).....short tons..	168,762	(1)	1.5	1.5	1
Nitrogen, agricultural [2] [4]............	36,192	27.9	4.6	32.5	37
Phosphate rock....thousand long tons..	92,838	44.4	0.1	44.5	46
Potash (K_2O equivalent).............	17,139	15.9	12.7	28.6	30
Salt [3]..............................	124,442	33.1	2.8	35.9	32
Sulfur, elemental...thousand long tons..	18,604	52.8	8.4	61.2	60
MINERAL ENERGY RESOURCES					
Crude petroleum.....thousand barrels..	14,083,717	23.6	7.4	31.0	32
Natural gas........million cubic feet..	31,028,664	62.3	....	62.3	64
Bituminous coal and lignite............	NA	NA	NA	NA	18
Anthracite............................	200,335	5.7	NA	NA	6

---

r Revised. p Preliminary. NA Not available. W Withheld to avoid disclosing company confidential data.

[1] Less than ½ unit.

[2] World total exclusive of U.S.S.R.

[3] Including Puerto Rico.

[4] Year ended June 30 of year stated.

Table 64.—Mineral commodity export price indexes

(1963 = 100)

Year and quarter	Metal ores	Fuels	Total
1965	114	101	104
1966	115	101	104
1967	109	101	103
1968:			
January to March	112	101	103
April to June	107	100	102
July to September	107	100	102
October to December	107	100	103
Average	109	100	102

Source: United Nations. Monthly Bulletin of Statistics. June 1969, special table D II, p. xix.

Table 65.—Analysis of export price indexes

(1963 = 100)

Year and quarter	Developed areas		Less-developed areas	
	Total minerals	Nonferrous base metals	Total minerals	Nonferrous base metals
1965	106	129	103	146
1966	107	144	103	177
1967	105	135	102	156
1968:				
January to March	107	156	102	192
April to June	104	136	102	158
July to September	104	137	102	152
October to December	104	139	102	158
Average	104	142	102	165

Source: United Nations. Monthly Bulletin of Statistics. June 1969, special table D III, p. xix.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/95

Technologic Trends in the Mineral Industries (Metals and Nonmetals Except Fuels)

By John L. Morning [1]

The everlasting battle to reduce costs in the mining industry marked the year as manufactures continued to develop larger mechanized equipment. To management, larger equipment means more output per man-hour, thereby combating ever increasing labor rates and declining grade of ore.

For open-pit mining, the first 200-ton haulage truck with a 1,650-horsepower unit was introduced and a 160-ton hauler was in operation. Large horsepower gas turbines were being tested and reportedly gave excellent performance, but with a 50-percent increase in fuel consumption. Gas turbines in the range of 1,000 to 1,800 horsepower were under development. To accompany the larger size haulage trucks, shovels of 25- to 30-cubic-yard capacity were being ordered to keep the mining equipment in balance. Front-end loaders continued to make inroads on shovels, and new models with 10- to 30-cubic-yard buckets were expected to continue the competition.[2]

Development of new mining techniques in the interest of cost reduction includes ramp-mining and the load-haul-dump (LHD) method of handling materials underground. The Creighton nickel mine of The International Nickel Company of Canada employs both methods in recovery of low-grade ore. The ramp-method of mine development allows the transfer of mechanized equipment to various parts of the mine, thus utilizing the high cost mechanical equipment to the fullest extent. The LHD method of material handling brings greater flexibility to mining operations and was rapidly gaining favor in Canada where over 30 mines either underdevelopment or in production will employ the method.[3] A high degree of interest was shown in tunneling technology. Nearly 500 engineers attended the first Tunnel and Shaft Excavation Symposium at the University of Minnesota, where new tunnel driving and support methods were discussed. The Bureau of Mines conducted a study on the state-of-the-art of horizontal boring technology.[4] Hard rock tunneling machines and economics of machine tunneling were reviewed.[5] Although most large-diameter tunnels in the past have driven for other industries, improved technology and economics suggests that boring of large-diameter tunnels for underground mines will be widely accepted by the mining industry.

In conventional tunnel driving, Granduc Operating Co. (Canada) broke the world's record by advancing the face 585 feet during a 6-day work week. Granduc was in the process of driving an 11-mile tunnel for development of its large copper mine.

---

[1] Physical scientist, Division of Mineral Studies.

[2] Engineering and Mining Journal. The Quiet Revolution in Open-Pit Mining Tools. V. 169, No. 9, September 1968, pp. 119–139.

Malone, V. F. Open-Pit Mining in 1968. Min. Cong. J., v. 55, No. 2, 1969, pp. 68–74.

[3] Clark, J. H. Load-Haul-Dump Method Revolutionizes Muck Handling Underground. Canadian Min. J., v. 89, No. 1, January 1968, pp. 23–27.

Mamen, C. Mining Technology. Canadian Min. J., v. 90, No. 2, February 1969, 239–243.

[4] Paone, James, William E. Bruce, and Roger J. Morrell. Horizontal Boring Technology: A State-Of-The-Art Study. BuMines Inf. Circ. 8392, 1968, 86 pp.

[5] Muirhead, I. R., and L. G. Glossop. Hard Rock Tunneling Machines. Inst. Min. and Met. (London), v. 77, No. 734 (Section A), January 1968, pp. A1–A21.

Worldwide, new mine developments and mine expansions continued at a record pace.[6] For most mineral commodities new production capacity continued to increase. The big rush to build iron ore pellet plants appeared to peak out as new high-grade iron ore mines were under development. Free world copper mine capacity was expected to increase 1.2 million tons of copper by 1972. Although the phosphate rock industry was faced with an oversupply situation, new capacity was being installed throughout the world. The domestic potash industry continued to be hurt with the development of new mines in Saskatchewan, Canada. Nickel, which has been in chronic short supply in recent years, was developing new capacity worldwide.

Total material handled at metal and nonmetal mines and quarries reached a record high tonnage, although crude ore production was about the same as in 1967. Copper, iron, and phosphate rock surface mines continued to dominate the lists of leading producers of crude ore and total material handled, sand and gravel plants excepted. Increased activity in the phosphate rock industry doubled the number of mines (from three to six) producing over 10 million tons of crude ore.

The average value of principal mineral products and byproducts increased significantly from $2.37 per ton in 1967 to $2.96 per ton in 1968. Although iron ore and phosphate rock, both large mineral commodities, decreased in average value per ton, the price advance for a considerable number of mineral commodities more than offset the loss. Average value of byproducts from metal and nonmetal mines increased from 1967 values.

Exploration and development work increased significantly for the year and was the highest on record. A high level of activity at uranium, copper, and tungsten mines accounted for most of the increased reported footage. Most of the material handled in development work was the result of stripping operations at copper, iron, and phosphate rock mines.

The industrial consumption of explosives in 1967 decreased for the first time since 1958, owing to the 6 months' work stoppage in the copper industry. Ammonium nitrate was the leading explosive consumed in the minerals industry.

Factors in selecting and applying commercial explosives and blasting agents were described in a Bureau of Mines report.[7]

Materials Handled.—Total quantity of ore and waste handled at metal and nonmetal mines and quarries in the United States reached a record high tonnage despite work stoppages in the copper industry during the first quarter. Total crude ore output was about the same as in 1967, as waste material handled accounted for the increased total. Mineral commodities that indicated a significant gain in total material handled compared with 1967 figures were barite, beryllium, copper, diatomite, phosphate rock, crushed and broken stone, and dimension stone. Total material handled decreased for asbestos, bauxite, boron minerals, clays, placer gold, iron ore, potassium salts, and sand and gravel. Of these mineral commodities, copper, diatomite, phosphate rock, crushed and broken stone, and dimension stone indicated increased output of crude ore while placer gold, boron minerals, potassium salts, and sand and gravel indicated a decrease in production of crude ore.

Reported material handled exceeded 100 million tons in 11 States. Arizona regained first place from Florida in total material handled owing to the settlement of labor problems in the copper industry and to the development of two large open-pit copper mines. Minnesota was the leader for output of crude ore. Twenty-eight States indicated an increase in output of crude ore, 12 States indicated a decrease in output, while eight States produced about the same quantity as in 1967. The combined States of Delaware and Hawaii indicated an increase in output of crude ore. Significant increases in crude ore handled occurred in Arizona, Illinois, Minnesota, and Utah.

Among the 25 leading metal mines in total material handled were 15 copper mines, seven iron mines, two molybdenum mines, and one uranium mine. Open-pit mining was used at all metal mines, with the exception of the molybdenum mine which employs block caving for mining.

---

[6] Engineering and Mining Journal. Mining Fattens Capacity at Record Rates. V. 169, No. 2, February 1968, pp. 75–110.

[7] Dick, Richard A. Factors In Selecting and Applying Commercial Explosives and Blasting Agents. BuMines Inf. Circ. 8405, 1968, 30 pp.

The uranium mine also employs some open stoping in addition to its open pit. Kennecott Copper Corp. regained the leadership in total material handled with the resumption of operations in the second quarter. The Anaconda Company and Duval Sierrita Corp. continued stripping operations in Arizona in the development of their large open-pit copper mines. Both concerns expected to be in operation by late 1969. The Hoyt Lake, Minn., open-pit iron ore mine of Pickands Mather & Co. continued to be the leading producer in output of ore as well as being the leading iron ore mine in terms of material handled.

Phosphate rock mines dominated the list of the 25 leading nonmetal mines, excluding sand and gravel operations. Continuing to head the list was the Kingsford, Fla., mine of International Minerals & Chemical Corp.

The Moss Landing, Calif., plant of Kaiser Aluminum & Chemical Corp. continued to lead in output of raw materials produced from lakes, pounds, seas, or wells.

Magnitude of the Mining Industry.—The number of mines reporting crude ore production, excluding sand and gravel plants, returned to the level of 1966 and was nearly 1,500 more than in 1963. Of the total 8,555 mines, 1,394 were classified as metal mines and 7,161 nonmetal mines. Compared with the number of mines reporting ore production in 1967, mineral commodity mines that significantly increased in number were as follows: Clays, 236; silver, 127; beryllium, 28; tungsten, 22; and crushed and broken stone, 22. Mineral commodities that significantly decreased in the number of reporting mines were zinc, 50; placer gold, 46; mercury, 34; and iron ore, 23.

The number of mines producing crude ore in excess of 10 million tons jumped to an unprecedented total of 18. With the return of production in the copper industry, the number of metal mines returned to 10, the same number as in 1965 and 1966. Nonmetalic mines in this category increased to eight as increased activity in the phosphate rock industry doubled the number of mines in that industry from three in 1967 to six in 1968. One boron mineral mine joined this class despite a drop in total output of boron minerals.

With the short supply of silver and more attractive price a number of mines entered the production picture, as silver mines increased by 127. Most of the increase was accounted for by mines producing less than 1,000 tons, but mines producing in the range of 1,000 to 100,000 tons increased by 20.

A renewed interest in beryllium increased the number of operating mines from five in 1967 to 33 in 1968. All of the mines were small with output under 10,000 tons each. High operating costs continued to plague placer gold mines, as the total number of mines dropped to 96 with most of the decrease accounted for in mines producing 100,000 to 1 million tons.

The average value of principal mineral products and byproducts rose significantly from $2.37 per ton in 1967 to $2.96 per ton in 1968. Excluding stone and sand and gravel mines, the average ton value increased to $6.06 from $4.93 in the previous year. Although individual mineral commodities registered a mixed gain or loss, the average ton value for metal mines increased $0.26 and for nonmetal mines $0.31. When stone and sand and gravel mines are excluded nonmetal mines indicated a decrease in value of $0.38 per ton. Iron ore and phosphate rock, both large volume mineral commodities, indicated a decrease in average value which was more than offset by price advances during the year of other mineral commodities.

Comparison of Production From Surface and Underground Mines.—Surface mining accounted for 94 percent of the ore mined and 95 percent of total material handled in 1968. These percentages have remained virtually constant during the past 10 years, although a slight trend persists for increased surface mining. Four mineral commodities, lead, manganese, potassium salts, and sodium carbonate (natural) were mined entirely by underground methods. Five metal ores, beryllium, placer gold, nickel, rare-earth metals, thorium, and titanium (ilmenite) were mined entirely by surface methods as were the nonmetals, emery, garnet, boron minerals, diatomite, feldspar, graphite, kyanite, lithium minerals, magnesite, marl, olivene, pumice, sand and gravel, sodium sulfate (natural), talc group minerals, and vermiculite.

Underground mining accounted for substantial percentage mined in five States, Colorado, 42 percent; New Mexico, 38 percent; Missouri, 28 percent; Kentucky, 21 percent; and Wyoming, 19 percent. Seventeen States reported no underground mines.

Ratio of Ore to Marketable Product.—The ratio of ore to marketable product varies for the various mineral commodities depending on grade of ore and type of valuable mineral content. The ratio for most mineral commodities with respect to time, indicates a rising ratio as the average grade or ore declines. Typical examples are in the copper industry where average grade or ore has steadily declined over the past years and iron ore, where new technology has allowed the recovery of iron ore pellets from low-grade taconite deposits. For 1968, most metal commodities indicated a higher ratio of ore to marketable products. For the nonmetals, about 50 percent indicated a higher ratio.

The ratio of material handled to marketable product also varies among the various mineral commodities and is affected mainly by the amount of development work and content of the valuable marketable material. For example, two large open-pit copper mines under development increased total material handled without contributing to the marketable product. For 1968, the ratios for all mines were mixed with about 50 percent indicating an increase in ratio.

Exploration and Development.—Reported footage for exploration and development at metal and nonmetal mines increased 32 percent compared with that in 1967, and was the highest on record. The increase was mainly attributed to the high level of activity at uranium mines. The footage for metal mines increased 38 percent with copper, tungsten, and uranium mines, indicating increased footage. Total footage for nonmetal mines decreased 18 percent despite increased activity at asbestos, barite, phosphate rock, and talc group mineral mines.

Colorado, New Mexico, Texas, Utah, and Wyoming accounted for the major share of total footage for exploration and development while Arizona, Florida, and Minnesota accounted for most of the total material handled. Stripping was the most important factor in movement of material handled and during the past 3 years, increased as follows: 1966, 485 million tons; 1967, 569 million tons; and 1968, 593 million tons. Most of the increase was the result of the development of large volume mines for commodities such as copper, iron, and phosphate rock. Noteworthy among new mines under development were Twin Buttes in Arizona (copper) and Duval Sieretta (copper-molybdenum).

Explosives.—Explosive statistics for the year of review are released too late to be incorporated in this chapter. For 1967, the industrial consumption of explosives decreased for the first time since 1958, the decrease being attributed to the 6-month-long copper strike. Although permissible explosives used in the minerals industry had remained relatively stable during the period 1961–66, consumption in 1967 decreased, continuing the overall trend which started in 1949. All of the decrease occurred in coal mining as the quantity used in metal mining was the highest since 1931 and the quantity used in quarrying and nonmetal mines reached a new high. Ammonium nitrate has been the preferred blasting agent in coal mining since it was introduced in 1956.

In the historical explosives consumption data presented in the 1967 chapter, ammonium nitrate blasting agents were included under high explosives other than permissibles. A 5-year breakout of ammonium nitrate blasting agents statistics indicate that more than 50 percent of the consumption of this explosive was in the coal mining industry. Both coal mining and quarrying and nonmetal mining consumption indicates a steady growth rate for this explosive while the growth rate was interrupted in the metal mining industry in 1967, owing to labor problems in the copper industry, as other metal mining industries operated at a normal pace.

The category of high explosives other than permissible explosives, excluding ammonium nitrate blasting agents, indicates a substantial increased consumption for these explosives during the past 5 years. The increase is probably explained by the fact that slurries and gels are included in the category.

Although once a prominent explosive, black-blasting powder used in the minerals industry continued to decrease dramatically in the past 5 years and will probably phase out entirely except for minor use.

Table 1.—Material handled at surface and underground mines, by commodities, in 1968

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
METALS									
Bauxite	[1] 2,345	[1] 2,340	[1] 4,685	W	W	W	2,345	2,340	4,685
Beryllium	15	2,795	2,810	-----	-----	-----	15	2,795	2,810
Copper	151,706	486,762	638,468	22,187	5,872	28,059	173,893	492,634	666,527
Gold:									
Lode	1,030	8,263	9,293	2,202	167	2,369	3,232	8,430	11,662
Placer	8,214	786	9,000	1	-----	1	8,215	786	9,001
Iron ore	202,126	155,010	357,136	14,300	2,508	16,808	216,426	157,518	373,944
Lead	319	13	332	7,799	594	8,393	8,118	607	8,725
Manganiferous ore	547	518	1,065	-----	-----	-----	547	518	1,065
Mercury	329	1,106	1,435	183	12	195	512	1,118	1,630
Molybdenum	4,595	16,500	21,095	16,454	61	16,515	21,049	16,561	37,610
Nickel	1,218	402	1,620	-----	-----	-----	1,218	402	1,620
Silver	182	100	282	756	213	969	938	313	1,251
Titanium: Ilmenite	22,141	3,621	25,762	-----	-----	-----	22,141	3,621	25,762
Tungsten	30	61	91	504	40	544	534	101	635
Uranium	2,193	34,584	36,777	3,729	1,282	5,011	5,922	35,866	41,788
Zinc	214	1,146	1,360	10,968	1,751	12,719	11,182	2,897	14,079
Other [2]	4,669	2,868	7,537	16	-----	16	4,685	2,868	7,553
Total metals	402,000	717,000	1,119,000	79,000	13,000	92,000	481,000	730,000	1,211,000
NONMETALS									
Abrasives [3]	150	124	274	44	-----	44	194	124	318
Asbestos	2,206	1,869	4,075	39	390	429	2,245	2,259	4,504
Barite	5,922	2,854	8,776	129	2,088	2,217	6,051	4,942	10,993
Boron minerals	16,438	-----	16,438	-----	-----	-----	16,438	-----	16,438
Clays	61,537	35,446	96,983	1,235	20	1,255	62,772	35,466	98,238
Diatomite	1,626	7,727	9,353	-----	-----	-----	1,626	7,727	9,353
Feldspar	1,427	296	1,723	2	7	9	1,429	303	1,732
Fluorspar	63	21	84	701	7	708	764	28	792
Gypsum	8,036	8,959	16,995	2,403	80	2,483	10,439	9,039	19,478
Mica	860	832	1,692	18	-----	18	878	832	1,710
Perlite	555	107	662	4	-----	4	559	107	666
Phosphate rock	145,402	282,177	427,579	1,236	7	1,243	146,638	282,184	428,822
Potassium salts	-----	-----	-----	16,899	145	17,044	16,899	145	17,044
Pumice	3,505	330	3,835	1	-----	1	3,506	330	3,836
Salt	5,313	43	5,356	13,124	226	13,350	18,437	269	18,706
Sand and gravel	810,480	-----	810,480	-----	-----	-----	810,480	-----	810,480
Sodium carbonate (natural)	13	-----	13	3,197	16	3,213	3,210	16	3,226
Stone:									
Crushed and broken	777,145	63,898	841,043	38,384	266	38,650	815,529	64,164	879,693
Dimension	8,808	1,239	10,047	328	-----	328	9,136	1,239	10,375

See footnotes at end of table.

Table 1.—Material handled at surface and underground mines, by commodities, in 1968—Continued

(Thousand short tons)

Commodity	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
NONMETALS—Continued									
Su fur:									
Frasch-process mines	8,353	----------	8,353	----------	----------	----------	8,353	----------	8,353
Other mines	4	----------	4	----------	----------	----------	4	----------	4
Talc, soapstone, and pyrophyllite	495	321	816	507	24	531	1,002	345	1,347
Vermiculite	1,377	3,789	5,116	----------	----------	----------	1,377	3,789	5,116
Other [4]	10,154	2,844	12,998	75	41	116	10,229	2,885	13,114
Total nonmetals	1,870,000	418,000	2,288,000	78,000	3,000	81,000	1,948,000	416,000	2,364,000
Grand total	2,272,000	1,130,000	3,402,000	157,000	16,000	173,000	2,429,000	1,146,000	3,574,000

W Withheld to avoid disclosing individual company data.

[1] Includes underground; Bureau of Mines not at liberty to publish separately.

[2] Magnesium, manganese, platinum-group metals, rare-earth metals, and vanadium.

[3] Emery, garnet, and tripoli.

[4] Aplite, graphite, greensand marl, kyanite, lithium minerals, magnesite, olivine, sodium sulfate (natural), and wollastonite.

Table 2.—Material handled at surface and underground mines (including sand and gravel and stone), by States, in 1968

(Thousand short tons)

State	Surface			Underground			All mines		
	Crude ore	Waste	Total	Crude ore	Waste	Total	Crude ore	Waste	Total
Alabama	31,676	26,045	57,721	2,031	229	2,260	33,707	26,274	59,981
Alaska	24,378	1,916	26,294	----------	----------	----------	24,378	1,916	26,294
Arizona	108,184	316,472	424,656	12,487	449	12,936	120,671	316,921	437,592
Arkansas	32,726	4,257	36,983	851	2	853	33,577	4,259	37,836
California	116,493	47,314	163,807	1,901	68	1,969	118,394	47,382	165,776
Colorado	25,497	727	26,224	18,183	1,097	19,280	43,680	1,824	45,504
Connecticut	16,164	340	16,504	----------	----------	----------	16,164	340	16,504
Florida	176,998	244,957	421,955	----------	----------	----------	176,998	244,957	421,955
Georgia	45,648	23,441	69,089	1,094	----------	1,094	46,742	23,441	70,183
Idaho	15,594	15,721	31,315	1,665	273	1,938	17,259	15,994	33,253
Illinois	101,334	6,187	107,521	2,917	5	2,922	104,251	6,192	110,443
Indiana	54,113	1,154	55,267	1,129	44	1,173	55,242	1,198	56,440
Iowa	44,149	11,908	56,057	1,946	----------	1,946	46,095	11,908	58,003
Kansas	26,378	1,054	27,432	2,779	----------	2,779	29,157	1,054	30,211
Kentucky	30,818	2,814	33,632	8,175	5	8,180	38,993	2,819	41,812

Louisiana	35,702	-----------	35,702	4,843	-----------	4,843	40,545	-----------	40,545
Maine	13,136	1,137	14,273	8	-----------	8	13,144	1,137	14,281
Maryland	26,053	503	26,556	189	15	204	26,242	518	26,760
Massachusetts	25,296	218	25,514	-----------	-----------	-----------	25,296	218	25,514
Michigan	127,114	15,395	142,509	14,612	536	15,148	141,726	15,931	157,657
Minnesota	192,544	77,747	270,291	-----------	7	7	192,544	77,654	270,298
Mississippi	14,508	1,604	16,112	-----------	-----------	-----------	14,508	1,604	16,112
Missouri	47,384	5,428	52,812	18,318	2,514	20,832	65,702	7,942	73,644
Montana	23,393	3,177	26,570	859	16	875	24,252	3,193	27,445
Nebraska	15,601	956	16,557	194	-----------	194	15,795	956	16,751
Nevada	26,883	44,352	71,235	156	23	179	27,039	44,375	71,414
New Hampshire	8,287	4	8,291	-----------	-----------	-----------	8,287	4	8,291
New Jersey	35,818	610	36,428	158	4	162	35,976	614	36,590
New Mexico	29,378	92,104	121,482	18,018	593	18,611	47,396	92,697	140,093
New York	88,820	8,430	97,250	5,750	407	6,157	94,570	8,837	103,407
North Carolina	44,084	20,916	65,000	10	-----------	10	44,094	20,916	65,010
North Dakota	10,126	-----------	10,126	-----------	-----------	-----------	10,126	-----------	10,126
Ohio	97,591	5,725	103,316	5,697	-----------	5,697	103,288	5,725	109,013
Oklahoma	21,472	6,614	28,086	1,372	5,620	6,992	22,844	12,234	35,078
Oregon	34,767	477	35,244	40	-----------	40	34,807	477	35,284
Pennsylvania	81,686	15,106	96,792	7,959	1,587	9,546	89,645	16,693	106,338
Rhode Island	2,701	-----------	2,701	-----------	-----------	-----------	2,701	-----------	2,701
South Carolina	17,391	2,333	19,724	-----------	-----------	-----------	17,391	2,333	19,724
South Dakota	13,402	277	13,679	2,003	138	2,141	15,405	415	15,820
Tennessee	43,191	2,898	46,089	7,762	700	8,462	50,953	3,598	54,551
Texas	93,191	2,879	96,070	386	16	402	93,577	2,895	96,472
Utah	46,457	72,395	118,852	3,220	304	3,524	49,677	72,699	122,376
Vermont	7,674	1,253	8,927	247	-----------	247	7,921	1,253	9,174
Virginia	42,775	1,946	44,721	2,364	675	3,039	45,139	2,621	47,760
Washington	46,020	62	46,082	638	2	640	46,658	64	46,722
West Virginia	12,964	1,162	14,126	2,256	20	2,276	15,220	1,182	16,402
Wisconsin	56,843	540	57,383	918	50	968	57,761	590	58,351
Wyoming	18,693	39,128	57,821	4,291	419	4,710	22,984	39,547	62,531
Other States [1]	7,951	26	7,977	-----------	-----------	-----------	7,951	26	7,977
Total	2,259,000	1,130,000	3,389,000	157,000	16,000	173,000	2,416,000	1,146,000	3,562,000

[1] Delaware and Hawaii.

Table 3.—Value of principal mineral products and byproducts of surface and underground ores mined in the United States in 1968

(Value per ton)

Ore	Surface			Underground			All mines		
	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total	Principal mineral product	Byproducts	Total
METALS									
Bauxite	$10.05	--------	$10.05	--------	--------	--------	$10.05	--------	$10.05
Beryllium	4.73	--------	4.73	--------	--------	--------	4.80	--------	4.80
Copper	5.29	$0.41	5.70	$7.63	$0.88	$8.51	5.60	$0.48	6.08
Gold:									
Lode	11,72	.10	11.82	12.70	2.42	15.12	12.37	1.65	14.02
Placer	.17	--------	.17	--------	--------	--------	.17	--------	.17
Iron ore	3.51	--------	3.51	7.11	.36	7.47	3.73	.02	3.75
Lead	.32	.19	.51	9.37	3.74	13.11	9.01	3.60	12.61
Mercury	26.18	.21	26.39	41.67	--------	41.67	32.00	.13	32.13
Molybdenum	3.64	--------	3.64	6.09	.27	6.36	5.62	.22	5.84
Platinum-group metals	.34	--------	.34	--------	--------	--------	.34	--------	.34
Silver	4.94	1.96	6.90	41.88	9.12	51.00	34.48	7.69	42.17
Titanium: Ilmenite	2.03	.34	2.37	--------	--------	--------	2.03	.34	2.37
Tungsten	6.83	--------	6.83	40.48	2.79	43.27	38.60	2.64	41.24
Uranium	28.11	.03	28.14	28.09	.09	28.18	28.10	.06	28.16
Zinc	20.36	7.72	28.08	10.56	3.00	13.56	10.75	3.09	13.84
Average value [1]	4.40	.17	4.57	9.48	1.33	10.81	5.25	.36	5.61
NONMETALS									
Abrasive stone	130.00	21.25	151.25	--------	--------	--------	130.00	21.25	151.25
Asbestos	4.45	.01	4.46	12.64	--------	12.64	4.59	.01	4.60
Barite	2.31	.01	2.32	13.59	--------	13.59	2.55	.01	2.56
Clays	3.73	--------	3.73	10.40	.02	10.42	3.87	--------	3.87
Diatomite	30.65	--------	30.65	--------	--------	--------	30.65	--------	30.65
Emery	20.28	--------	20.28	--------	--------	--------	20.28	--------	20.28
Feldspar	5.57	.46	6.03	1.00	.50	1.50	5.56	.46	6.02
Fluorspar	18.06	1.07	19.13	14.66	4.69	19.35	14.93	4.40	19.33
Garnet	19.16	--------	19.16	--------	--------	--------	19.16	--------	19.16
Graphite	289.66	--------	289.66	--------	--------	--------	289.66	--------	289.66
Gypsum	3.17	.03	3.20	4.25	--------	4.25	3.42	.02	3.44
Kyanite	9.59	.28	9.87	--------	--------	--------	9.59	.28	9.87
Lithium minerals	5.55	1.42	6.97	--------	--------	--------	5.55	1.42	6.97
Magnesite	2.91	.11	3.02	--------	--------	--------	2.91	.11	3.02
Mica: Flake	2.62	--------	2.62	5.50	--------	5.50	2.68	--------	2.68
Olivine	14.23	--------	14.23	--------	--------	--------	14.23	--------	14.23
Perlite	7.22	--------	7.22	6.50	--------	6.50	7.21	--------	7.21
Phosphate rock	1.62	--------	1.62	8.38	--------	8.38	1.66	--------	1.66
Potassium salts	--------	--------	--------	4.10	--------	4.10	4.10	--------	4.10
Pumice	2.55	--------	2.55	--------	--------	--------	2.55	--------	2.55
Salt	16.52	.52	17.04	6.58	.46	7.04	9.54	.48	10.02
Sand and gravel	1.25	--------	1.25	--------	--------	--------	1.25	--------	1.25

Stone:									
Crushed and broken	1.43	--------	1.43	2.06	--------	2.06	1.46	--------	1.46
Dimension	10.32	.32	10.64	18.71	1.35	20.06	10.62	.35	10.97
Sulfur:									
Frasch	36.03	--------	36.03	--------	--------	--------	36.03	--------	36.03
Other	11.50	--------	11.50	--------	--------	--------	11.50	--------	11.50
Talc, soapstone, and pyrophyllite	5.80	--------	5.80	7.29	--------	7.29	6.54	--------	6.54
Tripoli	15.00	--------	15.00	21.20	--------	21.20	18.21	--------	18.21
Vermiculite	4.13	--------	4.13	--------	--------	--------	4.13	--------	4.13
Average value [1]	1.91	.02	1.93	4.15	.12	4.27	2.03	.02	2.05
Average value—metal and nonmetals [1]	2.59	.04	2.63	6.83	.73	7.56	2.87	.09	2.96
Average value—nonmetals (excluding stone, sand, and gravel) [1]	3.55	.10	3.65	6.01	.23	6.24	3.84	.12	3.96
Average value—metals and nonmetals (excluding stone, sand, and gravel [1]	5.35	.15	5.50	8.32	.97	9.29	5.79	.27	6.06

[1] Including unpublished data.

Table 9.—Shipments of bituminous coal for consumption in Iowa, by district of origin and consumer use [1]

(Thousand short tons)

Use	District of origin [2]									Total
	7 and 8	9	10	11	12	15	17	19	20	
1964:										
Electric utilities	-----	-----	1,397	1	747	174	-----	-----	-----	2,319
Retail dealers	193	162	132	9	4	40	7	-----	1	548
All others	59	32	1,510	93	261	27	-----	-----	-----	1,982
Total	252	194	3,039	103	1,012	241	7	-----	1	4,849
1965:										
Electric utilities	-----	54	1,593	-----	724	392	-----	-----	-----	2,763
Retail dealers	207	181	124	10	2	34	7	-----	1	566
All others	89	47	1,672	60	272	39	-----	-----	-----	2,179
Total	296	282	3,389	70	998	465	7	-----	1	5,508
1966:										
Electric utilities	-----	179	1,653	-----	731	352	-----	-----	-----	2,915
Retail dealers	185	127	98	4	1	21	6	-----	-----	442
All others	97	67	1,577	29	260	53	-----	-----	-----	2,083
Total	282	373	3,328	33	992	426	6	-----	-----	5,440
1967:										
Electric utilities	-----	225	1,950	-----	683	369	-----	-----	-----	3,227
Retail dealers	133	136	75	-----	-----	5	6	-----	-----	355
All others	67	58	1,544	77	191	30	-----	-----	-----	1,967
Total	200	419	3,569	77	874	404	6	-----	-----	5,549
1968:										
Electric utilities	-----	W	2,240	-----	666	W	-----	17	-----	3,426
Retail dealers	112	W	56	-----	-----	W	6	-----	-----	263
All others	56	W	1,485	29	124	W	-----	-----	-----	1,788
Total	168	418	3,781	29	790	268	6	17	-----	5,477

W Withheld to avoid disclosing individual company confidential data; included with "Total."

[1] Data are based on voluntary reports submitted on separate distribution survey and may not agree with data derived from mine production survey.

[2] States or portion of States represented by each district are as follows: District 7 and 8—eastern Kentucky, southwestern Virginia, southern West Virginia, and north central Tennessee; 9—western Kentucky; 10—Illinois; 11—Indiana; 12—Iowa; 15—Kansas, Missouri, and northeastern Oklahoma; 17—western Colorado and northeastern New Mexico; 19—Wyoming and Idaho; 20—Utah.

Table 5.—Crude ore and total material handled at surface and underground mines, by States, in 1968

(Percent)

	Crude ore		Total material			Crude ore		Total material	
	Surface	Underground	Surface	Underground		Surface	Underground	Surface	Underground
STATE									
Alabama	94	6	96	4	Nebraska	99	1	99	1
Alaska	100	-----	100	-----	Nevada	99	1	100	-----
Arizona	90	10	97	3	New Hampshire	100	-----	100	-----
Arkansas	97	3	97	3	New Jersey	100	-----	100	-----
California	98	2	99	1	New Mexico	62	38	87	13
Colorado	58	42	58	42	New York	94	6	94	6
Connecticut	100	-----	100	-----	North Carolina	100	-----	100	-----
Delaware	100	-----	100	-----	North Dakota	100	-----	100	-----
Florida	100	-----	100	-----	Ohio	94	6	95	5
Georgia	97	3	98	2	Oklahoma	94	6	80	20
Hawaii	100	-----	100	-----	Oregon	100	-----	100	-----
Idaho	92	8	94	6	Pennsylvania	91	9	91	9
Illinois	97	3	97	3	Rhode Island	100	-----	100	-----
Indiana	98	2	98	2	South Carolina	100	-----	100	-----
Iowa	96	4	97	3	South Dakota	87	13	87	13
Kansas	90	10	91	9	Tennessee	86	14	84	16
Kentucky	79	21	80	20	Texas	100	-----	100	-----
Louisiana	88	12	88	12	Utah	94	6	97	3
Maine	100	-----	100	-----	Vermont	97	3	97	3
Maryland	99	1	99	1	Virginia	95	5	94	6
Massachusetts	100	-----	100	-----	Washington	99	1	99	1
Michigan	90	10	90	10	West Virginia	85	15	86	14
Minnesota	100	-----	100	-----	Wisconsin	98	2	98	2
Mississippi	100	-----	100	-----	Wyoming	81	19	92	8
Missouri	72	28	72	28					
Montana	96	4	97	3	Total	94	6	95	5

Table 6.—Number of domestic metal and nonmetal mines in 1968, by commodity and magnitude of crude ore production

Commodity	Total number of mines	Less than 1,000 tons	1,000 to 10,000 tons	10,000 to 100,000 tons	100,000 to 1,000,000 tons	1,000,000 to 10,000,000 tons	More than 10,000,000 tons
METALS							
Bauxite	11	-------	1	6	4	-------	-------
Beryllium	33	6	27	-------	-------	-------	-------
Copper	128	63	11	11	17	22	4
Gold:							
Lode	79	70	4	2	2	1	-------
Placer	96	67	11	11	5	2	-------
Iron ore	98	3	9	19	31	31	5
Lead	86	61	10	4	9	2	-------
Manganese ore	1	-------	-------	1	-------	-------	-------
Mercury	85	50	18	17	-------	-------	-------
Molybdenum	3	-------	-------	-------	-------	2	1
Silver	201	167	24	9	1	-------	-------
Titanium: Ilmenite	4	-------	-------	-------	1	3	-------
Tungsten	40	33	4	2	1	-------	-------
Uranium	397	133	84	56	124	-------	-------
Zinc	123	23	14	35	50	1	-------
Other [1]	9	3	-------	1	3	2	-------
Total metals	1,394	679	217	174	248	66	10
NONMETALS							
Abrasives [2]	20	9	7	4	-------	-------	-------
Asbestos	8	1	1	3	3	-------	-------
Barite	42	3	12	16	10	1	-------
Boron minerals	3	-------	-------	-------	-------	2	1
Clays	1,516	73	291	777	375	-------	-------
Diatomite	12	3	2	2	5	-------	-------
Feldspar	65	39	7	14	5	-------	-------
Fluorspar	22	7	7	6	2	-------	-------
Gypsum	77	4	9	27	37	-------	-------
Kyanite	4	-------	-------	-------	4	-------	-------
Marl, greensand	2	1	1	-------	-------	-------	-------
Mica: Flake	18	2	8	5	3	-------	-------
Olivine	5	1	2	2	-------	-------	-------
Perlite	14	4	5	3	2	-------	-------
Phosphate rock	48	1	3	2	18	18	6
Potassium salts	10	-------	-------	-------	3	7	-------
Pumice	139	24	48	41	26	-------	-------
Salt	56	1	11	11	27	6	-------
Sodium carbonate (natural)	4	-------	-------	1	1	2	-------
Stone:							
Crushed and broken	4,449	226	522	1,542	1,909	249	1
Dimension	544	201	223	90	29	1	-------
Sulfur:							
Frasch-process mines	20	-------	1	4	12	3	-------
Other mines	1	-------	1	-------	-------	-------	-------
Talc, soapstone, and pyrophyllite	62	11	27	23	1	-------	-------
Vermiculite	5	1	1	1	1	1	-------
Wollastonite	2	-------	1	1	-------	-------	-------
Other [3]	13	-------	2	4	6	1	-------
Total nonmetals	7,161	612	1,192	2,579	2,479	291	8
Grand total	8,555	1,291	1,409	2,753	2,727	357	18

[1] Antimony. magnesium, manganiferous ore, nickel, rare-earth metals, tin, and vanadium.

[2] Emery, garnet, and tripoli.

[3] Aplite, graphite, lithium minerals, magnesite, and sodium sulfate (natural).

Table 7.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1968, in order of output of ore

Mine	State	Operator	Commodity	Mining method
METALS				
Hoyt Lake	Minn	Pickands Mather & Co	Iron ore	Open pit.
Peter Mitchell	Minn	Reserve Mining Co	do	Do.
Utah Copper	Utah	Kennecott Copper Corp	Copper	Do.
Minntac	Minn	United States Steel Corp	Iron ore	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Climax	Colo	American Metal Climax, Inc.	Molybdenum	Caving.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Open pit.
Pima	Ariz	Pima Mining Co	Copper	Do.
Empire	Mich	Cleveland Cliffs Iron Co	Iron ore	Do.
San Manuel	Ariz	Magma Copper Co	Copper	Caving.
Berkeley Pit	Mont	The Anaconda Company	do	Open pit.
New Cornelia	Ariz	Phelps Dodge Corp	do	Do.
Republic	Mich	Cleveland Cliffs Iron Co	Iron ore	Do.
Butler	Minn	Hanna Mining Co	do	Do.
White Pine	Mich	White Pine Copper Co	Copper	Open stopes.
Ray Pit	Ariz	Kennecott Copper Corp	do	Open pit.
Trail Ridge	Fla	E.I. du Pont de Nemours & Co. Inc.	Ilmenite	Dredging.
Highland	Fla	do	do	Do.
Mineral Park	Ariz	Duval Corp	do	Do.
Yerington	Nev	The Anaconda Company	do	Do.
Inspiration	Ariz	Inspiration Consolidated Copper Co.	do	Do.
Chino	N.Mex	Kennecott Copper Corp	do	Do.
Mission	Ariz	American Smelting and Refining Company.	do	Do.
Thunderbird	Minn	Oglebay Norton Co	Iron ore	Do.
Esperanza	Ariz	Duval Corp	Copper	Do.
NONMETALS				
Kingsford	Fla	International Minerals & Chemical Corp.	Phosphate rock	Do.
Noralyn	Fla	do	do	Do.
Payne Creek	Fla	Agrico Chemical Co	do	Do.
Suwannee	Fla	Occidental Chemical Corp	do	Do.
Boron	Calif	United States Borax & Chemical Corp.	Boron	Do.
Palmetto	Fla	Agrico Chemical Co	Phosphate rock	Do.
Sydney	Fla	American Cyanamid Co	do	Do.
Fort Meade	Fla	Mobil Chemical Co	do	Do.
Bonny Lake	Fla	W.R. Grace & Co	do	Do.
Silver Peak	Nev	Foote Mineral Co	Lithium	Do.
Bartow	Fla	USS Agricultural Chemical Co.	Phosphate rock	Do.
Saddle Creek	Fla	Agrico Chemical Co	do	Do.
Clear Spring	Fla	Mobil Chemical Co	do	Do.
Silver City	Fla	Swift & Co	do	Do.
Chicora	Fla	American Cyanamid Co	do	Do.
Rockland	Fla	USS Agricultural Chemical Co.	do	Do.
Tenoroc	Fla	Bordon Chemical Co	do	Do.
Lee Creek	N. C.	Texas Gulf Sulphur Co	do	Do.
Folkston	Ga	Humphreys Mining Co	Ilmenite	Dredging.
Watson	Fla	Swift & Co	Phosphate rock	Open pit.
Retsof	N.Y	International Salt Co	Salt	Open stopes.
Shafts 1	N.Mex	Southwest Potash Co	Potassium salts	Do.
	N. Mex	Potash Co. of America	do	Do.
Phosphate	Fla	U.S. Phosphoric Products Co.	Phosphate rock	Open pit.
Gay	Idaho	J.R. Simplot Co	do	Do.

---

[1] Sand and gravel, stone, brines and materials from wells, etc., excepted.

Table 8.—Twenty-five leading metal and nonmetal[1] mines in the United States in 1968 in order of output of total materials handled

Mine	State	Operator	Commodity	Mining method
		METALS		
Utah Copper	Utah	Kennecott Copper Corp	Copper	Open pit.
Twin Buttes	Ariz	The Anaconda Company	do	Do.
Sierrita	Ariz	Duval Sierrita Corp	do	Do.
Hoyt Lake	Minn	Pickands Mather & Co	Iron ore	Do.
Tyrone	N. Mex	Phelps Dodge Corp	Copper	Do.
Peter Mitchell	Minn	Reserve Mining Co	Iron ore	Do.
Pima	Ariz	Pima Mining Co	Copper	Do.
Eagle Mountain	Calif	Kaiser Steel Corp	Iron ore	Do.
Morenci	Ariz	Phelps Dodge Corp	Copper	Do.
Lavender Pit	Ariz	do	do	Do.
Minntac	Minn	United States Steel Corp	Iron ore	Do.
Ray Pit	Ariz	Kennecott Copper Corp	Copper	Do.
New Cornelia	Ariz	Phelps Dodge Corp	do	Do.
Chino	N. Mex	Kennecott Copper Corp	do	Do.
Mission	Ariz	American Smelting and Refining Company.	do	Do.
Veteran	Nev	Kennecott Copper Corp	do	Do.
Russellville	Ala	United States Pipe & Foundry Co.	Iron ore	Do.
Questa	N. Mex	Molybdenum Corporation of America.	Molybdenum	Do.
TSG-1 + Dave	Wyo	Petrotomics Co	Uranium	Open pit, open stopes.
Mineral Park	Ariz	Duval Corp	Copper	Open pit.
Climax	Colo	American Metal Climax, Inc.	Molybdenum	Caving.
Sherman	Minn	United States Steel Corp	Iron ore	Open pit.
Esperanza	Ariz	Duval Corp	Copper	Do.
Empire	Mich	Cleveland Cliffs Iron Co	Iron ore	Do.
Inspiration	Ariz	Inspiration Consolidated Copper Co.	Copper	Do.
		NONMETALS		
Kingsford	Fla	International Minerals & Chemical Co.	Phosphate rock	Open pit.
Noralyn	Fla	do	do	Do.
Payne Creek	Fla	Agrico Chemical Co	do	Do.
Suwannee	Fla	Occidental Chemical Co	do	Do.
Palmetto	Fla	Agrico Chemical Co	do	Do.
Sydney	Fla	American Cyanamid Co	do	Do.
Lee Creek	N. C	Texas Gulf Sulphur Co	do	Dredging.
Bonny Lake	Fla	W.R. Grace & Co	do	Open pit.
Fort Meade	Fla	Mobil Chemical Co	do	Do.
Saddle Creek	Fla	Agrico Chemical Co	do	Do.
Tenoroc	Fla	Borden Chemical Co	do	Do.
Gay	Idaho	J.R. Simplot Co	do	Do.
Rockland	Fla	USS Agricultural Chemical Co.	do	Do.
Bartow	Fla	do	do	Do.
Boron	Calif	United States Borax & Chemical Corp.	Boron	Do.
Huber	Ga	J.M. Huber Corp	Clay	Do.
Clear Springs	Fla	Mobil Chemical Co	Phosphate rock	Do.
Silver City	Fla	Swift & Co	do	Do.
Chicora	Fla	American Cyanamid Co	do	Do.
Phosphat	Fla	U.S. Phosphoric Products Co.	do	Do.
Griffin	Ga	Freeport Kaolin Co	Clay	Do.
Watson	Fla	Swift & Co	Phosphate rock	Do.
Silver Peak	Nev	Foote Mineral Co	Lithium	Do.
Orange Park	Fla	American Cyanamid Co	Phosphate rock	Do.
Libby	Mont	W.R. Grace & Co	Vermiculite	Do.

---

[1] Sand and gravel, stone, brines and materials from wells, etc, excepted.

Table 9.—Twenty leading plants in the United States that produced nonmetallics and other materials from lakes, ponds, seas, or wells, in order of output of raw materials

Plant	State	Operator	Commodity
Magnesia	Calif	Kaiser Aluminum & Chemical Corp	Magnesium compounds.
Cape May	N.J.	Northwest Magnesite Co	Do.
Chula	Calif	FMC Corp	Do.
Trona	Calif	American Potash & Chemical Corp	Boron.
Nichols	Ala	Olin Mathiesen Chemical Corp	Salt Brine.
Columbia	Ark	Dow Chemical Co	Bromine.
Freeport	Texas	do	Salt brine.
South San Francisco	Calif	Merck & Co. Inc	Magnesium compounds.
Westend	Calif	Stauffer Chemical Co	Boron.
Arkansas Chemical	Ark	Arkansas Chemicals Inc	Bromine.
Union	Ark	Great Lakes Chemical Corp	Do.
Wyandotte	Mich	Wyandotte Chemical Corp	Salt brine.
Cane Creek	Utah	Texas Gulf Sulphur Co	Potassium salts.
Iberville	La	The Dow Chemical Co	Salt brine.
Boling Dome	Texas	Texas Gulf Sulphur Co	Frasch sulfur.
Tully	N.Y.	Allied Chemical Corp	Salt brine.
Plaguemine	La	do	Do.
Grand Isle	La	Freeport Sulphur Co	Frasch sulfur.
Painesville	Ohio	Diamond Shamrock Co	Salt brine.
Grand Ecaille	La	Freeport Sulphur Co	Frasch sulfur.

Table 10.—Kind of surface mining operation, by commodities and States, in 1968

(Percent of crude ore)

	Strip and single bench	Multiple bench
COMMODITY		
METALS		
Bauxite	67	33
Copper	16	84
Gold: Lode	-----	100
Iron ore	13	87
Mercury	54	46
Nickel	-----	100
Rare-earth metals and thorium	-----	100
Uranium	16	84
Zinc	4	96
NONMETALS		
Abrasives:		
Emery	100	-----
Garnet	25	75
Tripoli	100	-----
Aplite	71	29
Asbestos	42	58
Barite	86	14
Boron minerals	-----	100
Clays	93	7
NONMETALS—Continued		
Diatomite	7	93
Feldspar	74	26
Fluorspar	30	70
Gypsum	88	12
Kyanite	25	75
Lithium minerals	-----	100
Marl, greensand	100	-----
Mica: Flake	84	16
Olivine	100	-----
Perlite	99	1
Phosphate rock	96	4
Pumice	98	2
Salt	100	-----
Sand and gravel	100	-----
Stone:		
Crushed and broken	74	26
Dimension	76	24
Talc, soapstone, and pyrophyllite	88	12
Vermiculite	20	80

	Strip and single bench	Multiple bench
STATE		
Alabama	91	9
Alaska	100	-----
Arizona	17	83
Arkansas	94	6
California	33	67
Colorado	97	3
Connecticut	89	11
Delaware	89	11
Florida	100	-----
Georgia	96	4
Hawaii	75	25
Idaho	41	59
Illinois	92	8
Indiana	91	9
Iowa	90	10
Kansas	100	-----
Kentucky	89	11
Louisiana	99	1
Maine	91	9
Maryland	68	32
Massachusetts	85	15
Michigan	60	40
Minnesota	22	78
Mississippi	100	-----
Missouri	81	19
Montana	81	19
Nebraska	91	9
Nevada	43	57
New Hampshire	96	4
New Jersey	79	21
New Mexico	37	63
New York	64	36
North Carolina	96	4
North Dakota	100	-----
Ohio	86	14
Oklahoma	96	4
Oregon	94	6
Pennsylvania	71	29
Rhode Island	85	15
South Carolina	87	13
South Dakota	98	2
Tennessee	94	6
Texas	95	5
Utah	15	85
Vermont	87	13
Virginia	66	34
Washington	98	2
West Virginia	71	29
Wisconsin	94	6
Wyoming	40	60

Table 11.—Ore treated or sold per unit of marketable product at surface and underground mines in the United States, by commodities, in 1968

Commodity	Unit of marketable product	Surface			Underground			Total		
		Ore (thousand short tons)	Marketable product, units	Ratio of units of ore to units of marketable product	Ore (thousand short tons)	Marketable product, units	Ratio of units of ore to units of marketable product	Ore (thousand short tons)	Marketable product, units	Ratio of units of ore to units of marketable product
METALS										
Bauxite	Thousand long tons	[1] 2,345	[1] 1,663	[1] 1.4:1	W	W	W	2,345	1,663	1.4:1
Copper	Thousand short tons	151,706	939	157.7:1	22,187	203	109.6:1	173,893	1,142	149.2:1
Gold:										
Lode	Thousand troy ounces	1,030	310	3.3:1	2,202	677	3.1:1	3,232	987	3.2:1
Placer	do	8,214	37	222.0:1	1	---------	---------	8,215	37	222.0:1
Iron ore	Thousand long tons	202,126	71,832	2.9:1	14,300	8,832	1.6:1	216,426	80,664	2.7:1
Lead	Thousand short tons	319	---------	---------	7,799	278	28.0:1	8,118	278	29.2:1
Mercury	Thousand flasks	329	14	21.5:1	183	14	12.9:1	512	28	17.2:1
Nickel	Thousand short tons	1,218	17	71.6:1	---------	---------	---------	1,218	17	71.6:1
Platinum-group metals	Thousand troy ounces	4,276	7	422.7:1	---------	---------	---------	4,276	7	422.7:1
Rare-earth minerals	Thousand short tons	193	17	11.3:1	---------	---------	---------	193	17	11.3:1
Silver	Thousand troy ounces	182	415	0.4:1	756	13,963	0.1:1	938	14,378	0.1:1
Titanium: Ilmenite	Thousand short tons	22,141	960	23.1:1	---------	---------	---------	22,141	960	23.1:1
Zinc	do	214	15	14.3:1	10,968	430	25.6:1	11,182	445	25.2:1
NONMETALS										
Aplite	Thousand long tons	337	106	3.2:1	---------	---------	---------	337	106	3.2:1
Asbestos	Thousand short tons	2,206	117	19.0:1	39	4	9.7:1	2,245	121	18.7:1
Barite	do	5,922	853	7.0:1	129	73	1.8:1	6,051	926	6.6:1
Boron minerals	do	16,438	1,026	24.5:1	---------	---------	---------	16,438	1,026	24.5:1
Clays	do	61,537	51,702	1.2:1	1,235	1,226	1.0:1	62,772	52,928	1.2:1
Emery	do	7	7	1.0:1	---------	---------	---------	7	7	1.0:1
Feldspar	Thousand long tons	1,427	591	2.2:1	2	---------	---------	1,429	591	2.2:1
Fluorspar	Thousand short tons	63	33	2.0:1	701	226	3.3:1	764	259	3.1:1
Garnet	do	98	19	5.1:1	---------	---------	---------	98	19	5.1:1
Gypsum	do	8,036	7,625	1.1:1	2,403	2,395	1.0:1	10,439	10,020	1.1:1
Kyanite	do	514	209	2.4:1	---------	---------	---------	514	209	2.4:1
Magnesite	do	472	593	1.0:1	---------	---------	---------	472	593	1.0:1
Mica, flake	do	860	82	10.6:1	18	10	1.8:1	878	92	9.6:1
Olivine	do	84	51	1.6:1	---------	---------	---------	84	51	1.6:1
Perlite	do	555	424	1.4:1	4	4	1.0:1	559	428	1.4:1
Phosphate rock	Thousand long tons	145,402	35,705	4.1:1	1,236	855	1.4:1	146,638	36,560	4.0:1
Potassium salts	Thousand short tons	---------	---------	---------	16,899	2,535	6.7:1	16,899	2,535	6.7:1
Pumice	do	3,505	3,547	1.0:1	1	1	1.0:1	3,506	3,548	1.0:1
Salt	do	5,313	5,239	1.0:1	13,124	12,223	1.0:1	18,437	17,462	1.0:1
Sand and gravel	do	810,480	810,480	1.0:1	---------	---------	---------	810,480	810,480	1.0:1
Sodium carbonate (natural)	do	13	30	4.5:1	3,197	1,722	1.8:1	3,210	1,752	1.8:1
Stone:										
Dimension	do	8,808	5,432	1.6:1	328	42	7.8:1	9,136	5,474	1.7:1
Crushed and broken	do	777,145	768,467	1.0:1	38,384	38,090	1.0:1	815,529	806,557	1.0:1
Sulfur:										
Frasch	Thousand long tons	8,353	6,645	1.1:1	---------	---------	---------	8,353	6,645	1.1:1
Other	do	4	3	1.3:1	---------	---------	---------	4	3	1.3:1
Talc, soapstone, and pyrophyllite	Thousand short tons	495	495	1.0:1	507	463	1.1:1	1,002	958	1.1:1
Tripoli	do	41	41	1.0:1	44	35	1.2:1	85	76	1.1:1
Vermiculite	do	1,377	290	4.7:1	---------	---------	---------	1,377	290	4.7:1

W Withheld to avoid disclosing individual company confidential data.

[1] Includes underground data; Bureau of Mines not at liberty to publish separately.

Table 12.—Material handled per unit of marketable product at surface and underground mines in the United States by commodities, in 1968

Commodity	Unit of marketable product	Surface			Underground			Total		
		Total material handled (Thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable products	Total material handled (Thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable products	Total material handled (Thousand short tons)	Marketable product, units	Ratio of units of material handled to units of marketable products
METALS										
Bauxite	Thousand long tons	[1] 4,685	[1] 1,663	2.8:1	W	W	W	4,685	1,663	2.8:1
Copper	Thousand short tons	638,468	939	679.9:1	28,059	203	109.6:1	666,527	1,142	583.6:1
Gold:										
Lode	Thousand troy ounces	9,293	810	30.0:1	2,369	677	3.5:1	11,662	987	3.2:1
Placer	do	9,000	37	243.2:1	1	---------	---------	9,001	37	243.3:1
Iron ore	Thousand long tons	357,136	71,832	5.0:1	16,808	8,832	1,9.1	373,944	80,664	4.6:1
Lead	Thousand short tons	332	---------	---------	8,393	278	30.2:1	8,725	278	31.4:1
Mercury	Thousand flasks	1,435	14	102.5:1	195	14	13.9:1	1,630	28	58.2:1
Nickel	Thousand short tons	1,620	17	95.3:1	---------	---------	---------	1,620	17	95.3:1
Platinum-group metals	Thousand troy ounces	4,276	7	610.8:1	---------	---------	---------	4,276	7	610.8:1
Rare-earth minerals	Thousand short tons	194	17	11.4:1	---------	---------	---------	194	17	11.4:1
Silver	Thousand troy ounces	282	415	0.7:1	969	13,963	0.1:1	1,251	14,378	0.1:1
Titanium: Ilmenite	Thousand short tons	25,762	960	23.1:1	---------	---------	---------	25,762	960	23.1:1
Zinc	do	1,360	15	90.7:1	12,719	430	29.6:1	14,079	445	31.6:1
NONMETALS										
Aplite	Thousand long tons	428	106	4.0:1	---------	---------	---------	428	106	4.0:1
Asbestos	Thousand short tons	4,075	117	34.8:1	429	4	107.2:1	4,504	121	37.2:1
Barite	do	8,776	853	10.3:1	2,217	73	30.4:1	10,993	926	11.9:1
Boron minerals	do	16,438	1,026	24.5:1	---------	---------	---------	16,438	1,026	24.5:1
Clays	do	96,983	51,702	1.9:1	1,255	1,226	1.0:1	98,238	52,928	1.8:1
Emery	do	7	7	1.0:1	---------	---------	---------	7	7	1.0:1
Feldspar	Thousand long tons	1,723	591	2.9:1	9	---------	---------	1,732	591	2.9:1
Fluorspar	Thousand short tons	84	33	2.5:1	708	226	3.1:1	792	259	3.0:1
Garnet	do	196	19	10.3:1	---------	---------	---------	196	19	10.3:1
Gypsum	do	16,995	7,625	2.2:1	2,483	2,395	1.0:1	19,478	10,020	1.9:1
Kyanite	do									
Magnesite	do	1,599	593	2.7:1	---------	---------	---------	1,599	593	2.7:1
Mica, flake	do	1,692	82	20.6:1	18	10	1.8:1	1,710	92	18.6:1
Olivine	do	86	51	1.7:1	---------	---------	---------	86	51	1.7:1
Perlite	do	662	424	1.6:1	4	4	1.0:1	666	428	1.5:1
Phosphate rock	Thousand long tons	427,579	35,705	12.0:1	1,243	855	1.5:1	428,822	36,560	11.7:1
Potassium salts	Thousand short tons	---------	---------	---------	17,044	2,535	6.7:1	17,044	2,535	6.7:1
Pumice	do	3,835	3,547	1.1:1	1	1	1.0:1	3,836	3,548	1.1:1
Salt	do	5,356	5,239	1.0:1	13,350	12,223	1.1:1	18,706	17,462	1.1:1
Sand and gravel	do	810,480	810,480	1.0:1	---------	---------	---------	810,480	810,480	1.0:1
Sodium carbonate (natural)	do	13	30	0.4:1	3,213	1,722	1.9:1	3,226	1,752	1.8:1
Stone:										
Dimension	do	10,047	5,432	1.8:1	328	42	7.8:1	10,375	5,474	1.9:1
Crushed and broken	do	841,043	768,467	1.1:1	38,650	38,090	1.0:1	879,693	806,557	1.1:1
Sulfur:										
Frasch	Thousand long tons	8,353	6,645	1.2:1	---------	---------	---------	8,353	6,645	1.2:1
Other	do	4	3	1.3:1	---------	---------	---------	4	3	1.3:1
Talc, soapstone, and pyrophyllite	Thousand short tons	816	495	1.6:1	531	463	1.1:1	1,347	958	1.4:1
Tripoli	do	67	41	1.6:1	44	35	1.2:1	111	76	1.5:1
Vermiculite	do	5,116	290	17.6:1	---------	---------	---------	5,116	290	17.6:1

W Withheld to avoid disclosing individual company confidential data.

[1] Includes underground data; Bureau of Mines not at liberty to publish separately.

Table 13.—Mining methods used in open-pit mining, by commodities, in 1968

(Percent)

Commodity	Total material handled: Preceded by drilling and blasting	Total material handled: Not preceded by drilling and blasting
METALS		
Bauxite	93	7
Beryllium	1	99
Copper	72	28
Gold:		
Lode	91	9
Placer	-----	100
Iron Ore	82	18
Lead	16	84
Mercury	42	58
Molybdenum	100	-------
Nickel	19	81
Platinum-group metals	-----	100
Rare-earth metals	100	-------
Silver	48	52
Titanium: Concentrate	49	51
Uranium	16	84
Zinc	57	43
NONMETALS		
Abrasive stone	50	50
Aplite	29	71
Asbestos	93	7
Barite	11	89
Clays	21	79
NONMETALS—Continued		
Diatomite	-----	100
Emery	100	-------
Feldspar	86	14
Fluorspar	69	31
Graphite	100	-------
Gypsum	86	14
Kyanite	95	5
Lithium minerals	22	78
Magnesite	100	-------
Mica: Flake	7	93
Olivine	44	56
Perlite	52	48
Phosphate rock	1	99
Pumice	-----	100
Sand and gravel	-----	100
Stone:		
Crushed and broken	93	7
Dimension	53	47
Sulfur: Other mines	100	-------
Talc, soapstone, and pyrophyllite	68	32
Vermiculite	56	44
Total	49	51

Table 14.—Exploration and development activity in the United States, by methods

Method	Metals: Feet	Metals: Percent of total	Nonmetals: Feet	Nonmetals: Percent of total	Total: Feet	Total: Percent of total
1967						
Shaft and winze sinking	20,829	0.5	2,347	0.5	23,176	0.5
Raising	176,318	1.0	8,061	.3	184,379	.9
Drifting and crosscutting	1,065,713	6.3	60,559	2.7	1,126,272	5.9
Diamond drilling	2,514,670	14.9	123,303	5.6	2,637,973	13.8
Churn drilling	202,991	1.2	9,425	.4	212,416	1.1
Rotary drilling	8,625,263	51.3	1,383,566	62.9	10,008,829	52.7
Percussion drilling	4,009,081	23.8	280,665	12.7	4,289,746	22.5
Trenching	67,483	.4	28,824	1.3	96,307	.5
Other	111,422	.6	300,993	13.6	412,415	2.1
Total	16,793,770	100.0	2,197,743	100.0	18,991,513	100.0
1968						
Shaft and winze sinking	22,842	0.7	1,962	0.5	24,804	0.5
Raising	183,071	.7	8,937	.4	192,008	.7
Drifting and crosscutting	830,816	3.5	30,393	1.6	861,209	3.4
Diamond drilling	2,422,242	10.4	129,712	7.2	2,551,954	10.2
Churn drilling	370,063	1.5	6,191	.3	376,254	1.5
Rotary drilling	16,428,468	70.8	1,043,740	57.9	17,472,208	69.9
Percussion drilling	2,635,803	11.3	410,042	22.7	3,045,845	12.1
Trenching	110,541	.4	11,255	.6	121,796	.4
Other	182,906	.7	158,758	8.8	341,664	1.3
Total	23,186,752	100.0	1,800,990	100.0	24,987,742	100.0

Table 15.—Exploration and development by methods and selected metals and nonmetals, in 1968

(Feet)

Commodity	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
METALS										
Beryllium	----------	----------	150	----------	2,000	----------	23,427	----------	----------	25,577
Copper	3,420	49,764	106,414	29,190	843,647	25,198	179,264	73,605	17,520	1,328,022
Gold	1,371	13,620	59,489	3,609	104,198	1,650	142,900	1,092	59	327,988
Iron ore	197	46,351	120,545	----------	178,753	1,666	56,844	1,500	1,558	407,414
Lead	1,927	14,683	70,003	48,281	279,011	39,301	36,977	12,016	82,704	584,903
Mercury	282	1,957	8,454	8,170	11,067	6,110	25,085	80,943	----------	142,068
Molybdenum	1,365	2,612	51,699	----------	118,039	----------	15,622	----------	----------	189,337
Silver	7,433	7,250	45,196	12,377	65,651	2,200	15,771	37,892	5,840	199,610
Tungsten	70	2,558	17,824	950	29,144	590	200	10,600	----------	61,436
Uranium	4,090	18,860	283,022	6,695	604,317	257,689	15,274,169	2,216,615	2	18,665,459
Zinc	2,687	25,416	64,268	1,269	181,616	28,584	39,720	198,753	55,910	598,173
Other [1]	----------	----------	4,252	----------	4,799	7,125	618,489	2,787	19,313	656,765
Total	22,842	183,071	830,816	110,541	2,422,242	370,063	16,428,468	2,635,803	182,906	23,186,752
NONMETALS										
Asbestos	----------	520	2,218	----------	----------	----------	11,385	----------	----------	14,123
Barite	----------	438	3,484	----------	----------	----------	9,460	2,228	----------	15,610
Clays	----------	----------	251	----------	----------	5,971	620,919	----------	152,514	779,655
Fluorspar	832	956	6,323	----------	62,966	220	1,350	4,256	----------	76,903
Gypsum	----------	600	3,675	----------	4,000	----------	61,524	----------	1	69,800
Mica: Flake	----------	----------	----------	100	----------	----------	672	----------	1	773
Phosphate rock	----------	----------	----------	----------	5,217	----------	280,556	----------	600	286,373
Stone	----------	1,750	6,235	11,081	14,437	----------	46,887	386,108	121	466,619
Talc, soapstone, and pyrophyllite	1,130	4,673	6,407	----------	39,974	----------	----------	13,450	----------	65,634
Other [2]	----------	----------	1,800	74	3,118	----------	10,987	4,000	5,521	25,500
Total	1,962	8,937	30,393	11,255	129,712	6,191	1,043,740	410,042	158,758	1,800,990
Grand total	24,804	192,008	861,209	121,796	2,551,954	376,254	17,472,208	3,045,845	341,664	24,987,742

[1] Bauxite, manganese ore, nickel, platinum metals, rare-earth metals, and vanadium.

[2] Boron minerals, diatomite, feldspar, perlite, pumice, salt, sulfur (Frasch), and sulfur (other).

Table 16.—Exploration and development by methods and States in 1968

(Feet)

State	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Diamond drilling	Churn drilling	Rotary drilling	Percussion drilling	Other	Total
Alabama	----------	----------	----------	----------	7,028	751	575,552	----------	1,291	584,622
Alaska	----------	----------	1,500	150	6,439	6,199	----------	----------	11,726	26,014
Arizona	1,910	45,755	77,600	5,976	453,134	24,898	223,568	52,151	4,510	889,502
Arkansas	----------	428	7,721	----------	17,453	----------	42,937	40,000	7,586	116,125
California	1,388	8,154	36,985	16,320	69,273	1,196	31,746	38,352	----------	208,414
Colorado	3,905	10,722	139,491	13,519	407,932	430	782,922	694,457	9	2,053,387
Florida	----------	----------	----------	----------	----------	----------	41,506	----------	----------	41,506
Georgia	----------	----------	----------	----------	----------	----------	124,000	----------	----------	124,000
Idaho	2,962	12,623	44,146	11,079	131,772	----------	190,812	10,153	23,280	426,827
Illinois	485	956	5,270	----------	56,527	1,420	620	----------	12,000	77,278
Indiana	----------	----------	----------	----------	----------	----------	720	----------	----------	720
Iowa	----------	----------	300	----------	984	----------	14,080	493	----------	15,857
Kansas	429	----------	----------	----------	96	1,034	63,853	----------	2,021	67,438
Kenutcky	85	500	1,560	----------	10,682	----------	5,000	2,500	----------	20,327
Maine	----------	----------	----------	----------	5,845	----------	----------	----------	----------	5,845
Michigan	663	18,163	61,621	----------	103,353	----------	----------	32,254	----------	216,054
Minnesota	758	----------	855	----------	240,879	915	8,060	2,787	----------	254,254
Missouri	65	15,700	82,884	38,892	211,493	45,272	43,011	40	75,889	512,746
Montana	6,656	510	4,047	5,700	6,088	----------	615	6,576	9,088	39,280
Nebraska	----------	----------	----------	----------	125	----------	----------	----------	----------	125
Nevada	1,102	1,381	9,527	13,682	32,627	5,910	166,538	50,687	21,687	303,141
New Jersey	----------	1,781	1,054	----------	----------	----------	----------	----------	----------	2,835
New Mexico	2,813	21,919	229,973	160	172,381	2,610	4,571,497	1,210,702	8	6,212,063
New York	56	15,078	11,974	----------	4,095	----------	3,000	----------	----------	34,203
North Carolina	----------	----------	----------	----------	30,950	----------	24	8,000	----------	38,974
Ohio	----------	----------	650	----------	----------	----------	----------	----------	----------	650
Oregon	26	18	918	108	----------	2,020	----------	----------	8,500	6,590
Pennsylvania	----------	8,356	10,624	----------	----------	----------	----------	----------	----------	18,980
South Carolina	----------	----------	----------	----------	----------	----------	672	189,353	----------	190,025
South Dakota	----------	11,064	53,089	----------	85,093	----------	272,550	----------	----------	421,796
Tennessee	----------	3,724	27,356	----------	56,903	----------	83,943	326,890	129,068	627,384
Texas	50	500	800	----------	9,000	----------	2,576,546	21,000	----------	2,607,896
Utah	1,196	8,040	36,289	11,680	277,807	800	1,034,382	355,950	273	1,726,417
Vermont	----------	600	1,420	----------	8,289	----------	----------	----------	----------	10,309
Virginia	----------	4,198	7,265	----------	----------	----------	48,724	----------	----------	60,187
Washington	55	1,038	3,298	20	14,372	----------	2,400	4,000	17,128	42,811
Wisconsin	200	----------	400	----------	10,467	26,300	37,450	----------	----------	74,817
Wyoming	----------	800	2,592	4,510	120,867	256,499	6,525,480	----------	23,100	6,933,848
Total	24,804	192,008	861,209	121,796	2,551,954	876,254	17,472,208	3,045,845	341,664	24,987,742

Table 17.—Total material (ore and waste) produced by exploration and development in the United States, by commodities and States, in 1968

(Thousand short tons)

	Shaft and winze sinking	Raising	Drifting and cross-cutting	Trenching	Stripping	Total
			COMMODITIES			
METALS						
Bauxite	---------	---------	13	---------	1,709	1,722
Beryllium	---------	---------	---------	---------	2,795	2,795
Copper	24	59	277	50	188,099	188,509
Gold:						
Lode	2	25	94	1	6,693	6,815
Placer	---------	---------	---------	2	38	40
Iron ore	2	50	457	---------	84,488	84,997
Lead	7	58	215	127	117	524
Mercury	1	4	16	173	447	641
Molybdenum	20	7	199	---------	---------	226
Silver	50	16	94	53	34	247
Tungsten	---------	6	66	6	61	139
Uranium	20	25	665	17	5,989	6,716
Zinc	21	37	241	6	3	308
Other [1]	---------	---------	---------	---------	519	519
Total metals [2]	149	291	2,340	436	290,995	294,211
NONMETALS						
Asbestos	---------	---------	3	---------	1	4
Barite	---------	---------	5	---------	85	90
Clays	---------	---------	1	---------	8,386	8,387
Feldspar	---------	---------	3	1	---------	4
Fluorspar	2	3	22	---------	4	31
Gypsum	---------	2	19	---------	6,024	6,045
Perlite						
Phosphate rock	---------	---------	---------	---------	265,126	265,126
Stone	---------	2	183	197	21,687	22,069
Talc, soapstone & pyrophylite	11	7	27	---------	137	182
Vermiculite						
Other [3]	---------	---------	4	---------	291	295
Total nonmetals [2]	13	14	268	198	301,742	302,235
Grand total [2]	161	305	2,607	635	592,736	596,444
			STATE			
Alabama	---------	---------	---------	---------	508	508
Alaska	---------	---------	3	---------	---------	3
Arizona	11	49	193	36	180,278	180,567
Arkansas	---------	---------	18	---------	1,669	1,687
California	11	15	304	31	430	791
Colorado	28	23	366	21	494	932
Florida	---------	---------	---------	---------	244,957	244,957
Georgia	---------	---------	---------	---------	3,918	3,918
Idaho	21	39	105	46	7	218
Illinois	1	3	20	---------	6,187	6,211
Indiana	---------	---------	---------	---------	1,198	1,198
Iowa	---------	---------	4	---------	11,908	11,912
Kansas	3	---------	---------	---------	20	23
Kentucky	---------	1	3	---------	81	85
Michigan	6	12	131	---------	15,398	15,547
Minnesota	6	---------	6	---------	75,990	76,002
Mississippi	---------	---------	---------	---------	60	60
Missouri	1	32	400	262	111	806
Montana	46	20	7	24	11	108
Nebraska	---------	---------	---------	---------	151	151
Nevada	2	3	18	185	6,989	7,197
New Jersey	---------	1	2	---------	---------	3
New Mexico	19	33	571	1	13,768	14,392
New York	-----------	14	30	---------	---------	44
North Carolina	---------	---------	---------	---------	19,175	19,175
Ohio	---------	---------	4	---------	---------	4
Oregon	---------	---------	2	---------	---------	2
Pennsylvania	---------	5	42	---------	---------	47
South Carolina	---------	---------	---------	---------	269	269
South Dakota	---------	20	87	---------	110	217
Tennessee	---------	4	155	---------	2,717	2,876
Texas	---------	1	1	---------	167	169
Utah	4	20	79	15	3,068	3,186

See footnotes at end of table.

Table 17.—Total material (ore and waste) produced by exploration and development in the United States, by commodities and States, in 1968—Continued

(Thousand short tons)

	Shaft and winze sining	Rising	Drifting and cross-cutting	Trenching	Stripping	Total
STATE—Continued						
Vermont		1	3			4
Virginia		4	30			34
Washington		4	11		1	16
Wisconsin	2		4		334	340
Wyoming		1	8	14	2,762	2,785
Total	161	305	2,607	635	592,736	596,444

[1] Manganiferous ore and rare-earths metal.
[2] Data may not add to totals shown because of independent rounding.
[3] Flake mica, pumice and salt.

Table 18.—U.S. consumption of industrial explosives

(Thousand pounds)

Year	Black blasting powder		High explosives		Blasting agents	Liquid oxygen explosives	Total
	Granular	Pelltets	Permis-sible	Other than permissible	Ammonium nitrate processed and unprocessed		
1963	502	636	76,319	422,779	953,854	1,834	1,455,924
1964	451	495	77,406	481,451	1,103,563	2,184	1,665,551
1965	464	372	76,040	542,318	1,260,107	5,598	1,884,900
1966	240	223	74,527	538,968	1,343,104	13,094	1,970,156
1967	242	182	68,770	537,997	1,287,506	10,017	1,904,714

Table 19.—U.S. consumption of explosives in the minerals industry

(Thousand pounds)

Year	Coal mining	Metal mining	Quarrying and nonmetal mining	Total
PERMISSIBLE EXPLOSIVES				
1963	75,150	74	560	75,784
1964	75,950	117	741	76,808
1965	73,564	79	1,520	75,163
1966	71,091	95	1,957	73,143
1967	65,284	161	2,238	67,683
OTHER HIGH EXPLOSIVES [1]				
1963	23,397	83,657	133,216	240,270
1964	23,557	119,782	133,022	276,361
1965	22,090	123,862	141,050	287,002
1966	19,591	118,900	141,117	279,608
1967	31,942	161,181	146,018	339,141
AMMONIUM-NITRATE BLASTING AGENTS				
1963	404,907	168,068	186,603	759,578
1964	447,145	198,395	227,290	872,830
1965	493,571	232,770	228,284	954,625
1966	514,549	234,336	252,794	1,001,679
1967	555,303	166,250	261,145	982,698
PELLET BLACK BLASTING POWDER				
1963	497	1	85	583
1964	341	-----------	48	389
1965	126	-----------	61	187
1966	77	-----------	25	102
1967	32	1	23	56
GRANULAR BLACK BLASTING POWDER				
1963	260	-----------	169	429
1964	108	6	145	259
1965	15	4	120	139
1966	245	-----------	390	635
1967	3	3	101	107
TOTAL EXPLOSIVES [1]				
1963	504,211	251,800	320,633	1,076,644
1964	547,101	318,300	361,246	1,226,647
1965	589,366	356,715	371,035	1,317,116
1966	605,553	353,331	396,283	1,355,167
1967	652,564	327,596	409,525	1,389,685

[1] Excludes liquid oxygen explosives

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/69

Statistical Summary

By Kathleen J. D'Amico [1]

This summary appears in Minerals Yearbook volumes I–II, and III, which cover mineral production in the United States, its island possessions, the Canal Zone, and the Commonwealth of Puerto Rico, as well as the principal minerals imported into and exported from the United States. The sections of this chapter and the area chapters in volume III contain further details on production. A summary table comparing world and U.S. mineral production also is included.

Mineral production may be measured at any of several stages of extraction and processing. The stage of measurement used in the chapter is normally what is termed "mine output." It usually refers to minerals in the form in which they are first extracted from the ground, but customarily includes for some minerals the product of auxiliary processing operations at or near mines.

Because of inadequacies in the statistics available, some series deviate from the foregoing definition. The quantities of gold, silver, copper, lead, zinc, and tin are recorded on a mine basis (as the recoverable content of ore sold or treated). The values assigned to these quantities, however, are based on the average selling price of refined metal, not the mine value. Mercury is measured as recovered metal and valued at the average New York price for metal.

The weight or volume units shown are those customary in the particular industries producing the respective commodities. No adjustment has been made in dollar values for changes in purchasing power of the dollar.

---

[1] Statistical officer, Minerals Yearbook.

Table 1.—Value of mineral production[1] in the United States, by mineral groups

(Millions)

Year	Mineral fuels	Nonmetals (except fuels)	Metals	Total [2]
1964	$13,623	$4,623	$2,366	$20,612
1965	14,047	4,933	2,544	21,524
1966	r 15,088	5,176	2,703	r 22,968
1967	r 16,195	r 5,206	2,333	r 23,734
1968	16,820	5,452	2,703	24,974

r Revised.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Data may not add to total shown because of independent rounding.

Table 2.—Mineral production[1] in the United States

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Mineral fuels:								
Asphalt and related bitumens (native):								
Bituminous limestone and sandstone and gilsonite short tons	1,911,664	$9,461	2,041,271	$8,438	1,866,666	$8,136	1,786,840	$8,127
Carbon dioxide, natural (estimate) thousand cubic feet	1,173,676	152	1,140,907	153	1,142,374	165	1,118,027	176
Coal:								
Bituminous and lignite[2] thousand short tons	512,088	2,276,022	533,881	2,421,293	552,626	2,555,377	545,245	2,546,340
Pennsylvania anthracite do	14,866	122,021	12,941	100,663	12,256	96,160	11,461	97,245
Helium:								
Crude thousand cubic feet	3,566,734	39,848	3,654,700	41,556	3,697,300	42,800	3,788,400	44,700
Grade A do	819,100	28,880	951,400	32,541	1,015,000	29,657	1,066,400	28,355
Natural gas million cubic feet	16,039,753	2,494,542	r 17,206,628	r 2,702,759	18,171,325	2,898,741	19,322,400	3,168,688
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	173,525	494,354	179,248	r 520,635	187,840	r 546,927	199,049	571,679
LP gases do	268,030	417,249	288,912	527,223	326,616	632,994	351,262	552,385
Peat short tons	608,746	6,080	605,858	6,501	619,687	6,768	619,161	7,230
Petroleum (crude) thousand 42-gallon barrels	2,848,514	3,158,299	r 3,027,763	r 3,726,423	[3] 3,216,715	[3] 9,377,516	3,329,042	9,794,826
Total mineral fuels	XX	14,047,000	XX	r 15,088,000	XX	r 16,195,000	XX	16,820,000
Nonmetals (except fuels):								
Abrasive stones[4] short tons	3,603	$432	3,806	$515	2,701	$574	3,141	$629
Asbestos do	118,275	10,162	125,928	11,056	123,189	11,102	120,690	10,406
Barite thousand short tons	852	10,192	947	11,259	962	11,604	927	13,706
Boron minerals do	807	64,180	866	68,209	955	74,130	1,026	79,827
Bromine thousand pounds	328,115	77,259	326,498	78,883	349,757	85,891	362,452	86,787
Calcite (optical grade) pounds	(5)	(5)	(5)	(5)	----------	----------	----------	----------
Calcium-magnesium chloride short tons	(5)	(5)	(5)	(5)	608,965	11,983	(5)	(5)
Cement:								
Portland thousand 376-pound barrels	366,802	1,154,448	378,091	1,162,984	365,570	1,148,208	388,525	1,227,942
Masonry thousand 280-pound barrels	23,260	65,979	22,367	63,407	21,700	62,168	23,167	66,259
Natural and slag thousand 376-pound barrels	279	1,027	109	415	94	360	86	332
Clays thousand short tons	55,126	204,932	56,713	221,714	54,664	223,987	57,283	246,898
Emery short tons	10,720	204	11,102	210	(5)	(5)	(5)	(5)
Feldspar long tons	624,598	6,263	655,452	7,020	615,397	7,086	667,679	8,265
Fluorspar short tons	240,932	10,889	253,068	10,841	295,643	13,164	252,411	11,656
Garnet (abrasive) do	19,330	1,717	21,952	2,092	20,494	1,849	22,136	1,922
Gem stones (estimate)	NA	2,218	NA	2,437	NA	2,480	NA	2,497
Gypsum thousand short tons	10,033	37,375	9,647	35,681	9,393	34,383	10,018	36,775
Lime do	16,794	232,939	18,057	239,588	[3] 17,985	[3] 240,216	18,687	249,639
Magnesium compounds from sea water and brine (except for metals) short tons, MgO equivalent	637,857	47,197	651,187	46,690	544,428	r 41,883	525,210	43,449
Mica:								
Scrap short tons	120,255	3,468	113,133	3,733	118,503	2,876	125,323	3,014
Sheet pounds	716,086	185	4,500	1	20,500	(5)	15,000	(5)

Perlite ... short tons	892,884	3,352	404,160	8,907	418,001	8,978	427,574	4,221
Phosphate rock ... thousand short tons	29,482	198,828	39,044	261,092	39,770	265,947	41,251	250,692
Potassium salts ... thousand short tons, K_2O equivalent	3,140	129,767	3,320	122,210	3,299	105,813	2,722	75,664
Pumice ... thousand short tons	3,371	6,550	3,218	6,765	3,446	5,181	3,580	5,570
Pyrites ... thousand long tons	875	5,383	873	5,088	861	7,943	872	(5)
Salt ... thousand short tons	34,687	215,699	36,463	229,985	38,946	251,210	41,274	272,275
Sand and gravel ... do	908,049	957,416	934,481	984,982	r 907,045	r 981,748	917,739	1,020,836
Sodium carbonate (natural) ... short tons	1,494,105	34,717	1,737,511	40,674	r 1,726,071	40,539	2,043,405	42,104
Sodium sulfate (natural) ... do	619,752	11,024	640,329	11,271	636,843	10,710	699,706	12,729
Stone [6] ... thousand short tons	780,242	1,208,831	813,374	1,260,715	785,592	1,240,244	819,403	1,317,753
Sulfur:								
Frasch process mines ... thousand long tons	7,251	164,654	7,721	201,292	7,682	251,670	6,645	268,146
Other mines ... long tons	2,852	11	557	5	568	3	3,125	46
Talc, soapstone, and pyrophyllite ... short tons	862,875	6,343	895,045	6,479	902,512	6,871	958,262	6,656
Tripoli ... do	71,138	381	66,168	828	70,984	877	85,534	796
Vermiculite ... thousand short tons	249	4,460	262	4,954	255	4,974	290	5,684
Value of items that cannot be disclosed: Aplite, brucite, diatomite, graphite, iodine, kyanite, lithium minerals, magnesite, greensand marl, olivine, staurolite, wollastonite, and values indicated by footnote 5	XX	65,028	XX	69,911	XX	55,734	XX	79,309
Total nonmetals	XX	4,938,000	XX	5,176,000	XX	5,206,000	XX	5,452,000
Metals:								
Antimony ore and concentrate short tons, antimony content	845	(7)	927	(7)	892	(7)	856	(7)
Bauxite ... thousand long tons, dried equivalent	1,654	$18,632	1,796	$20,095	1,654	$19,079	1,665	$23,752
Beryllium concentrate ... short tons, gross weight	(7)	(7)	(7)	(7)	(7)	(7)	168	81
Copper (recoverable content of ores, etc.) ... short tons	1,351,734	957,028	1,429,152	1,033,850	954,064	729,401	1,204,621	1,008,195
Gold (recoverable content of ores, etc.) ... troy ounces	1,705,190	59,682	1,803,420	63,119	1,584,187	55,447	1,478,292	[8] 58,038
Iron ore, usable (excluding byproduct iron sinter) thousand long tons, gross weight	84,079	801,388	90,040	854,134	82,415	817,511	81,934	836,433
Lead (recoverable content of ores, etc.) ... short tons	301,147	93,959	327,368	98,964	316,931	88,741	359,156	94,903
Manganese ore (35 percent or more Mn) short tons, gross weight	29,258	(7)	14,406	(7)	12,585	(7)	11,378	(7)
Manganiferous ore (5 to 35 percent Mn) ... do	332,763	(7)	324,926	(7)	289,160	(7)	244,590	(7)
Mercury ... 76-pound flasks	19,582	11,176	22,008	9,722	23,784	11,639	28,874	15,464
Molybdenum (content of concentrate) ... thousand pounds	77,310	120,801	91,670	144,827	81,596	138,604	93,245	151,000
Nickel (content of ore and concentrate) ... short tons	16,188	(7)	15,036	(7)	15,287	(7)	17,294	(7)
Silver (recoverable content of ores, etc.) thousand troy ounces	39,806	51,469	43,669	56,463	r 32,845	r 50,135	32,729	70,191
Tin (content of concentrate) ... long tons	47	126	97	265	(7)	(7)	(7)	(7)
Titanium concentrate, ilmenite short tons, gross weight	948,882	18,058	868,436	17,608	882,414	18,519	960,118	19,484
Tungsten ore and concentrate short tons, 60 percent WO_3 basis	7,949	13,028	8,912	17,620	9,088	20,895	10,704	25,197
Uranium (recoverable content U_3O_8) ... thousand pounds	19,727	157,828	19,037	152,281	20,655	165,239	24,139	182,698
Vanadium (recoverable in ore and concentrate) short tons	5,226	18,284	5,166	22,210	4,968	21,831	6,483	28,143
Zinc (recoverable content of ores, etc.) ... do	611,153	178,284	572,558	166,044	549,413	151,562	529,446	142,950

See footnote at end of table.

Table 2.—Mineral production[1] in the United States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Value of items that cannot be disclosed: Cobalt, columbium-tantalum concentrate (1967), magnesium chloride for magnesium metal, manganiferous residuum, platinum-group metals (crude), rare-earth metal concentrates, titanium concentrate (rutile), zirconium concentrate, and values indicated by footnote 7	XX	$44,804	XX	$46,615	XX	$50,190	XX	$51,030
Total metals	XX	2,544,000	XX	2,703,000	XX	2,333,000	XX	2,703,000
Grand total mineral production	XX	21,524,000	XX	r 22,968,000	XX	r 23,734,000	XX	24,974,000

[r] Revised. NA Not available. XX Not applicable.
[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).
[2] Includes small quantity of anthracite mined in States other than Pennsylvania.
[3] Final figure; supersedes figure given in commodity section.
[4] Grindstones, pulpstones, millstones (weight not recorded), grinding pebbles, sharpening stones, and tube-mill liners.
[5] Figure withheld to avoid disclosing individual company confidentila data; value included with "Nonmetal items that cannot be disclosed."
[6] Excludes abrasive stone, bituminous limestone, bituminous sandstone, and ground soapstone, all included elsewhere in table.
[7] Figure withheld to avoid disclosing individual company confidential data; value included with "Metal items that cannot be disclosed."
[8] Based on average U.S. Treasury price ($35.00) Jan. 1, 1968 through Mar. 15, 1968, and the New York selling price for the remainder of the year.

Table 3.—Minerals produced in the United States and principal producing States in 1968

Mineral	Principal producing States in order of quantity	Other producing States
Antimony	Idaho, Alaska.	
Aplite	Va.	
Asbestos	Calif., Vt., Ariz., N.C.	
Asphalt	Tex., Utah, Ala., Ky	Mo.
Barite	Mo., Nev., Ark., Ga	Alaska, Calif., N.C., Tenn.
Bauxite	Ark., Ala., Ga.	
Beryllium	Colo., S. Dak., N. Mex.	
Boron	Calif.	
Bromine	Mich., Tex., Ark., Calif.	
Brucite	Nev.	
Calcium-magnesium chloride	Mich., Calif.	
Carbon dioxide	N. Mex., Colo., Calif., Utah.	
Cement	Calif., Pa., Tex., Mich	Ala., Ariz., Ark., Colo., Fla., Ga., Hawaii, Idaho., Ill., Ind., Iowa, Kans., Ky., La., Maine, Md., Minn., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N.C., Ohio, Okla., Oreg., S.C., S. Dak., Tenn., Utah, Va., Wash., W. Va., Wis., Wyo.
Clays	Ga., Ohio, Tex., N.C	All other States except Alaska, R.I.
Coal	W. Va., Ky., Pa., Ill	Ala., Alaska, Ark., Colo., Ind., Iowa, Kans., Md., Mo., Mont., N. Mex., N. Dak., Ohio, Okla., Tenn., Utah, Va., Wash., Wyo.
Cobalt	Pa.	
Columbium-tantalum	S. Dak.	
Copper	Ariz., Utah, N. Mex., Nev	Alaska, Calif., Colo., Idaho, Maine, Mich., Mo., Mont., Okla., Oreg., Pa., Tenn., Wash.
Diatomite	Calif., Nev., Wash., Ariz	Oreg.
Emery	N.Y.	
Feldspar	N.C., Calif., Conn., Ga	Ariz., Colo., Maine, N.H., N. Mex., S.C., S. Dak., Va., Wyo.
Fluorspar	Ill., Ky., Mont., Colo	Ariz., Nev., N. Mex., Utah.
Garnet, abrasive	N.Y., Idaho.	
Gold	S. Dak., Utah, Nev., Ariz	Alaska, Calif., Colo., Idaho, Mont., N. Mex., Oreg., Pa., Tenn., Wash.
Graphite	Tex.	
Gypsum	Mich., Calif., Iowa, Tex	Ariz., Ark., Colo., Idaho, Ind., Kans., La., Mont., Nev., N. Mex., N.Y., Ohio, Okla., S. Dak., Utah, Va., Wash., Wyo.
Helium	Kans., Tex., Okla., Ariz	N. Mex.
Iodine	Mich.	
Iron ore	Minn., Mich., Calif., Wyo	Ala., Ariz., Colo., Ga., Idaho, Miss., Mo., Mont., Nev., N.J., N. Mex., N.Y., Pa., Tex., Utah, Va.
Kyanite	Va., Ga., S.C., Fla.	
Lead	Mo., Idaho, Utah, Colo	Alaska, Ariz., Calif., Ill., Kans., Ky., Mont., Nev., N. Mex., N.Y., Okla., Va., Wash., Wis.
Lime	Ohio, Pa., Mich., Mo	Ala., Ariz., Ark., Calif., Colo., Conn., Fla., Hawaii, Idaho, Ill., Ind., Iowa, Kans., La., Md., Mass., Minn., Miss., Mont., Nebr., Nev., N.J., N. Mex., N.Y., N. Dak., Okla., Oreg., S. Dak., Tenn., Tex., Utah, Vt., Va., Wash., W. Va., Wis., Wyo.
Lithium	N.C., Nev., Calif., S. Dak.	
Magnesite	Nev., Wash.	
Magnesium chloride	Tex.	
Magnesium compounds	Mich., Tex., Calif., N.J	Fla., Miss., Utah.
Manganese ore	N. Mex., Mont.	
Manganiferous ore	Minn., N. Mex., Mont.	
Manganiferous residuum	N.J.	
Marl, greensand	N.J., Md.	
Mercury	Calif., Nev., Idaho, Oreg	Alaska, Ariz., Tex., Wash.
Mica:		
Scrap	N.C., Ala., Ga., S.C	Ariz., Calif., Conn., N. Mex., Pa., S. Dak.
Sheet	N.C.	
Molybdenum	Colo., Ariz., Utah., N. Mex	Calif., Nev.
Natural gas	Tex., La., Okla., N. Mex	Ala., Alaska., Ariz., Ark., Calif., Colo., Fla., Ill., Ind., Kans., Ky., Md., Mich., Miss., Mo., Mont., Nebr., N.Y., N. Dak., Ohio., Pa., Tenn., Utah, Va., W. Va., Wyo.

Table 3.—Minerals produced in the United States and principal producing States in 1968—Continued

Mineral	Principal producing States in order of quantity	Other producing States
Natural gas liquids	Tex., La., Okla., N. Mex	Ark., Calif., Colo., Fla., Ill., Kans., Ky., Mich., Miss., Mont., Nebr., N. Dak., Pa., Utah., W. Va., Wyo.
Nickel	Oreg.	
Olivine	Wash., N.C.	
Peat	Mich., Ill., N.J., Ind	Calif., Colo., Fla., Ga., Idaho, Iowa, Maine, Md., Mass., N. Mex., N.Y., N. Dak., Ohio, Oreg., Pa., S.C., Vt., Wash., Wis.
Perlite	N. Mex., Ariz., Nev., Calif	Colo., Idaho.
Petroleum	Tex., La., Calif., Okla	Ala., Alaska, Ariz., Ark., Colo., Fla., Ill., Ind., Kans., Ky., Mich., Miss., Mo., Mont., Nebr., Nev., N. Mex., N.Y., N. Dak., Ohio., Pa., S. Dak., Tenn., Utah, Va., W. Va., Wyo.
Phosphate rock	Fla., Idaho, Tenn., N.C	Calif., Mont., Utah, Wyo.
Platinum-group metals	Alaska, Calif.	
Potassium salts	N. Mex., Utah, Calif., Mich	Md.
Pumice	Ariz., Calif., Oreg., Hawaii	Colo., Idaho, Kans., Mont., Nebr., Nev., N. Mex., Okla., Tex., Utah, Wash.
Pyrites	Tenn., Pa., Colo., Ariz	S.C., Utah.
Rare-earth metals	Calif., Ga., Fla., Colo.	
Salt	La., Tex., Ohio, N.Y	Ala., Calif., Colo., Hawaii, Kans., Mich., Nev., N. Mex., N. Dak., Okla., Utah, Va., W. Va.
Sand and gravel	Calif., Mich., Ohio, Ill	All other States.
Silver	Idaho, Utah, Ariz., Mont	Alaska, Calif., Colo., Maine, Mich., Mo., Nev., N. Mex., N.Y., Okla., Oreg., Pa., S. Dak., Tenn., Wash.
Sodium carbonate	Wyo., Calif.	
Sodium sulfate	Calif., Tex., Wyo.	
Staurolite	Fla.	
Stone	Pa., Ill., Tex., Ohio	All other States.
Sulfur (Frasch)	La., Tex.	
Sulfur, ore	Calif.	
Talc soapstone, and pyrophyllite.	N.Y., Calif., Vt., Tex	Ala., Ark., Ga., Md., Mont., Nev., N.C., Oreg., Pa., Va., Wash.
Tin	Colo., Alaska.	
Titanium	N.Y., Fla., N.J., Ga	Va.
Tripoli	Ill., Okla., Ark., Pa.	
Tungsten	Calif., Colo., Mont., Nev	Ariz., Idaho, Utah.
Uranium	N. Mex., Wyo., Colo., Utah	Ariz., N. Dak., S. Dak., Tex.
Vanadium	Colo., Ark., Idaho, Utah	Ariz., N. Mex.
Vermiculite	Mont., S.C., Tex., Ariz.	
Wollastonite	N.Y., Calif.	
Zinc	Tenn., N.Y., Idaho, Colo	Ariz., Calif., Ill., Kans., Ky., Maine, Mo., Mont., Nev., N.J., N. Mex., Okla., Pa., Utah, Va., Wash., Wis.
Zirconium	Fla., Ga.	

Table 4.—Value of mineral production in the United States, and principal minerals produced in 1968

(Thousands)

State	Value	Rank	Percent of U.S. total	Principal minerals in order of value
Alabama	$259,621	22	1.04	Coal, cement, stone, petroleum.
Alaska	221,717	25	.89	Petroleum, sand and gravel, coal, natural gas.
Arizona	617,541	10	2.47	Copper, molybdenum, cement, sand and gravel.
Arkansas	198,723	28	.80	Petroleum, natural gas, bauxite, stone.
California	1,808,147	3	7.24	Petroleum, natural gas, sand and gravel, cement.
Colorado	359.458	17	1.44	Molybdenum, petroleum, coal, sand and gravel.
Connecticut	23,876	45	.10	Stone, sand and gravel, feldspar, lime.
Delaware	1,996	50	.01	Sand and gravel, stone, clays, gem stones.
Florida	304,623	18	1.22	Phosphate rock, stone, cement, clays.
Georgia	173.090	29	.69	Clays, stone, cement, sand and gravel.
Hawaii	23,225	46	.09	Stone, cement, sand and gravel, pumice.
Idaho	114,253	32	.46	Silver, phosphate rock, zinc, lead.
Illinois	647,543	8	2.59	Coal, petroleum, stone, sand and gravel.
Indiana	235,386	23	.94	Coal, cement, stone, petroleum.
Iowa	117,297	31	.47	Cement, stone, sand and gravel, gypsum.
Kansas	568,701	12	2.28	Petroleum, natural gas, helium, natural gas liquids.
Kentucky	534,863	15	2.14	Coal, stone, petroleum, natural gas.
Louisiana	4,321,010	2	17.30	Petroleum, natural gas, natural gas liquids, sulfur.
Maine	17,810	47	.07	Cement, sand and gravel, stone, zinc.
Maryland	71,844	38	.29	Stone, cement, sand and gravel, coal.
Massachusetts	43,340	43	.17	Sand and gravel, stone, lime, clays.
Michigan	627,075	9	2.51	Iron ore, cement, copper, sand and gravel.
Minnesota	567,427	13	2.27	Iron ore, sand and gravel, stone, cement.
Mississippi	220,955	26	.88	Petroleum, natural gas, sand and gravel, clays.
Missouri	275,955	21	1.10	Cement, stone, lead, iron ore.
Montana	228,131	24	.91	Petroleum, copper, sand and gravel, cement.
Nebraska	74,837	37	.30	Petroleum, cement, sand and gravel, stone.
Nevada	120,041	30	.48	Copper, gold, sand and gravel, diatomite.
New Hampshire	9,166	48	.04	Sand and gravel, stone, clays, feldspar.
New Jersey	77,466	36	.31	Sand and gravel, stone, zinc, magnesium compounds.
New Mexico	893,775	7	3.58	Petroleum, natural gas, uranium, copper.
New York	299,636	19	1.20	Cement, stone, sand and gravel, salt.
North Carolina	82,819	34	.33	Stone, sand and gravel, phosphate rock, cement.
North Dakota	98,036	33	.39	Petroleum, sand and gravel, coal, natural gas.
Ohio	536,898	14	2.15	Coal, stone, sand and gravel, cement.
Oklahoma	1,016,832	4	4.07	Petroleum, natural gas, natural gas liquids, stone.
Oregon	64,449	40	.26	Sand and gravel, stone, cement, nickel.
Pennsylvania	904,044	6	3.62	Coal, cement, stone, sand and gravel.
Rhode Island	4,222	49	.02	Sand and gravel, stone, gem stones.
South Carolina	51,858	42	.21	Cement, stone, clays, sand and gravel.
South Dakota	54,086	41	.22	Gold, sand and gravel, stone, cement.
Tennessee	201,334	27	.81	Stone, zinc, cement, coal.
Texas	5,505,831	1	22.05	Petroleum, natural gas, natural gas liquids, cement.
Utah	423,951	16	1.70	Copper, petroleum, coal, molybdenum.
Vermont	28,715	44	.11	Stone, asbestos, sand and gravel, talc.
Virginia	295,663	20	1.18	Coal, stone, cement, sand and gravel.
Washington	81,385	35	.33	Sand and gravel, cement, stone, zinc.
West Virginia	917,708	5	3.67	Coal, natural gas, stone, natural gas liquids.
Wisconsin	71,695	39	.29	Sand and gravel, stone, zinc, cement.
Wyoming	576,190	11	2.31	Petroleum, uranium, natural gas, sodium salts.
Total	24,974,244	--	100.00	Petroleum, natural gas, coal, stone.

Table 5.—Mineral production[1] in the United States, by States

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ALABAMA								
Cement:[2]								
Portland ... thousand 376-pound barrels	13,765	$42,604	16,394	$49,537	15,364	$46,510	15,514	$48,147
Masonry ... thousand 280-pound barrels	2,598	7,853	2,570	7,613	2,377	6,938	2,523	7,309
Clays ... thousand short tons	[3] 2,220	[3] 4,888	2,448	5,142	2,724	7,422	2,798	6,995
Coal (bituminous) ... do	14,832	106,249	14,219	100,112	15,486	110,696	16,440	115,815
Iron ore (usable) ... thousand long tons, gross weight	1,495	8,241	1,508	8,702	1,472	8,286	1,151	6,730
Lime ... thousand short tons	653	7,905	699	8,442	624	7,719	773	8,933
Natural gas ... million cubic feet	203	26	252	32	248	31	230	30
Petroleum (crude) ... thousand 42-gallon barrels	8,064	21,047	8,030	20,878	7,848	19,500	7,635	20,385
Sand and gravel ... thousand short tons	6,422	7,195	7,082	7,953	7,229	7,969	8,140	9,130
Stone ... do	[4] 17,987	[4] 30,810	[4] 20,744	[4] 36,839	18,371	33,346	20,643	33,847
Value of items that cannot be disclosed: Native asphalt, bauxite, slag cement, clays (kaolin 1965, bentonite 1965), scrap mica, salt, stone (dimension limestone 1965–66, dimension marble 1965–66, shell 1965, crushed sandstone 1965–66), talc, and tripoli (1965)	XX	9,446	XX	4,528	XX	2,974	XX	2,300
Total	XX	246,264	XX	249,778	XX	251,391	XX	259,621
ALASKA								
Antimony ore and concentrate ... short tons, antimony content	1	$1	8	W	10	W	3	W
Barite ... thousand short tons	---------	---------	W	W	W	W	91	W
Coal (bituminous) ... do	893	6,095	927	$6,953	925	$7,296	750	$4,502
Copper (recoverable content of ores, etc.) ... short tons	32	23	W	W	W	W	W	W
Gold (recoverable content of ores, etc.) ... troy ounces	42,249	1,479	27,325	956	22,948	803	21,262	[5] 835
Lead (recoverable content of ores, etc.) ... short tons	9	3	14	4	---------	---------	W	W
Natural gas ... million cubic feet	7,255	1,799	11,267	2,794	14,438	3,610	17,343	4,388
Peat ... short tons	1,967	16	W	W	1,528	12	---------	---------
Petroleum (crude) ... thousand 42-gallon barrels	11,128	34,073	14,358	44,007	29,126	91,164	66,204	186,695
Sand and gravel ... thousand short tons	30,266	34,467	17,457	21,793	22,370	26,248	18,013	20,366
Silver (recoverable content of ores, etc.) ... thousand troy ounces	8	10	7	9	6	9	4	8
Value of items that cannot be disclosed: Gem stones, mercury, platinum-group metals, stone, tin, uranium ore (1965) and values indicated by symbol W	XX	5,512	XX	6,167	XX	4,924	XX	4,923
Total	XX	83,478	XX	82,683	XX	134,066	XX	221,717
ARIZONA								
Asbestos ... short tons	3,469	$441	W	W	W	W	W	W
Clays ... thousand short tons	[3] 129	[3] 164	[3] 89	[3] $121	[3] 67	[3] $37	77	$347
Coal (bituminous) ... do	---------	---------	---------	---------	1	5	---------	---------
Copper (recoverable content of ores, etc.) ... short tons	703,377	497,991	739,569	535,004	501,741	388,591	627,961	525,566
Diatomite ... do	295	8	1,358	36	W	W	W	W

Fluorspar do	--------	--------	--------	--------	10,000	280	--------	--------
Gem stones	NA	120	NA	120	NA	150	NA	149
Gold (recoverable content of ores, etc.) troy ounces	150,481	5,265	142,528	4,988	80,844	2,830	95,999	[5] 3,769
Gypsum thousand short tons	103	540	75	394	W	W	W	W
Helium, grade A thousand cubic feet	58,000	2,030	63,500	2,222	73,800	2,066	64,800	1,600
Iron ore (usable) thousand long tons, gross weight	8	51	W	W	W	W	16	124
Lead (recoverable content of ores, etc.) short tons	5,913	1,845	5,211	1,575	4,771	1,336	1,704	450
Lime thousand short tons	204	3,543	218	3,721	186	3,142	260	4,561
Mercury 76-pound flasks	158	90	363	160	W	W	192	103
Molybdenum (content of concentrate) thousand pounds	9,399	15,880	10,161	17,812	9,261	15,385	12,127	19,207
Natural gas million cubic feet	8,106	376	3,161	436	1,255	193	881	142
Petroleum (crude) thousand 42-gallon barrels	97	W	132	370	2,924	8,188	3,370	9,606
Pumice thousand short tons	1,161	1,515	1,103	1,674	1,064	904	1,033	974
Sand and gravel do	14,918	16,621	18,730	20,448	[r] 18,463	[r] 18,409	13,981	14,423
Silver (recoverable content of ores, etc.) thousand troy ounces	6,095	7,881	6,339	8,196	4,588	7,112	4,958	10,633
Stone thousand short tons	2,474	4,171	2,271	4,091	1,910	3,491	3,293	6,239
Tungsten ore and concentrate short tons, 60-percent WO_3 basis	3	5	2	5	W	W	1	3
Uranium (recoverable content U_3O_8) thousand pounds	W	W	437	3,492	83	666	295	1,923
Vanadium (recoverable in ore and concentrate) short tons	W	381	W	453	W	W	W	W
Zinc (recoverable content of ores, etc.) do	21,757	6,353	15,985	4,636	14,330	3,967	5,441	1,469
Value of items that cannot be disclosed: Cement, clays (bentonite 1965–67), feldspar, scrap mica, perlite, pyrites, vermiculite (1967–68), and values indicated by symbol W	XX	17,847	XX	12,125	XX	13,503	XX	16,253
Total	XX	583,118	XX	622,079	XX	[r] 465,255	XX	617,541

ARKANSAS

Barite thousand short tons	249	$2,379	233	$2,266	229	$2,266	166	$3,839
Bauxite thousand long tons, dried equivalent	1,593	17,974	1,718	19,439	1,571	18,269	1,582	23,058
Bromine and bromine in compounds thousand pounds	32,254	7,171	42,307	10,467	64,450	14,885	95,499	20,790
Clays thousand short tons	866	1,890	[3] 775	[3] 776	941	1,740	919	2,134
Coal (bituminous) do	226	1,643	236	1,640	189	1,427	211	1,576
Gem stones	NA	31	NA	35	NA	35	NA	30
Lime thousand short tons	192	2,776	207	3,004	187	2,723	206	3,058
Natural gas million cubic feet	82,831	12,922	105,174	16,407	116,522	17,828	156,627	24,456
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	662	1,578	763	1,923	656	1,780	753	2,192
LP gases do	1,661	3,139	1,540	3,233	1,279	3,009	1,435	2,899
Petroleum (crude) do	25,930	68,974	23,824	63,372	21,075	56,902	19,464	53,137
Sand and gravel thousand short tons	12,806	15,836	16,056	21,038	14,239	15,531	12,997	14,643
Stone do	21,241	26,778	19,109	24,588	17,454	23,236	16,322	22,256
Value of items that cannot be disclosed: Abrasive stones, cement, clays (kaolin and fire clay 1966), gypsum, iron ore (1965), mercury (1966–67) phosphate rock (1965–66), soapstone, tripoli, vanadium (1968), and values indicated by symbol W	XX	16,019	XX	21,939	XX	19,822	XX	24,655
Total	XX	179,110	XX	190,127	XX	179,453	XX	198,723

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
CALIFORNIA								
Antimony ore and concentrate..........short tons, antimony content..	---------	---------	1	(6)	---------	---------	---------	---------
Asbestos..........short tons..	74,587	$6,177	81,671	$6,945	77,091	$6,726	75,592	$6,139
Barite..........thousand short tons..	4	21	15	104	10	71	W	W
Boron minerals..........do....	807	64,180	866	68,209	955	74,130	1,026	79,827
Cement..........thousand 376-pound barrels..	45,352	144,852	45,387	146,302	42,034	137,961	47,595	151,961
Clays..........thousand short tons..	3,207	7,226	2,984	6,708	2,609	6,037	2,755	6,680
Copper (recoverable content of ores, etc.)..........short tons..	1,165	825	1,078	780	788	602	1,182	989
Feldspar..........long tons..	95,975	W	100,915	W	94,769	W	W	W
Gem stones..........	NA	200	NA	200	NA	200	NA	200
Gold (recoverable content of ores, etc.)..........troy ounces..	62,885	2,201	64,764	2,267	40,570	1,420	15,682	[5] 616
Gypsum..........thousand short tons..	1,611	3,881	1,207	3,064	1,241	3,150	1,360	3,603
Lead (recoverable content of ores, etc.)..........short tons..	1,810	565	1,976	597	1,735	486	4,001	1,057
Lime..........thousand short tons..	602	11,073	552	8,764	539	8,696	568	9,301
Magnesium compounds from sea water and bitterns (partly estimated) short tons, MgO equivalent..........	95,652	7,955	87,816	7,413	76,592	6,882	81,622	7,229
Mercury..........76-pound flasks..	13,404	7,650	16,070	7,100	16,385	8,018	21,417	11,470
Natural gas..........million cubic feet..	660,384	204,059	r 689,607	r 204,059	681,080	202,290	714,893	221,077
Natural gas liquids:								
Natural gasoline and cycle products..thousand 42-gallon barrels..	15,614	49,850	15,110	r 48,867	14,605	r 46,620	13,403	42,963
LP gases..........do....	8,073	15,467	8,409	17,304	8,730	19,065	8,589	18,749
Peat..........short tons..	30,905	434	29,235	384	30,014	396	W	W
Perlite..........do....	W	W	W	W	W	W	8,806	80
Petroleum (crude)..........thousand 42-gallon barrels..	316,428	753,099	345,295	812,834	359,219	829,133	375,496	883,644
Pumice..........thousand short tons..	676	1,744	580	1,763	866	1,357	776	1,312
Salt..........do....	1,638	W	1,693	W	1,732	W	1,901	W
Sand and gravel..........do....	118,310	136,227	120,692	139,157	116,125	139,212	124,655	153,360
Silver (recoverable content of ores, etc.)..........thousand troy ounces..	197	254	190	246	145	224	598	1,282
Stone..........thousand short tons..	42,575	59,668	43,051	61,336	37,186	55,263	36,125	52,671
Sulfur ore..........long tons..	360	2	557	5	568	3	3,125	46
Talc, soapstone, and pyrophyllite..........short tons..	141,074	1,725	138,340	1,847	143,466	1,945	165,396	2,075
Tin (content of concentrate)..........long tons..	W	W	13	21	W	W	---------	---------
Zinc (recoverable content of ores, etc.)..........short tons..	225	66	335	97	441	122	3,525	952
Value of items that cannot be disclosed: Bromine, calcite (optical grade, 1965–66), calcium-magnesium chloride, carbon dioxide, coal (lignite), diatomite, iodine (1965–66), iron ore, lithium minerals, scrap mica, molybdenum, phosphate rock (1968), platinum group metals (crude), potassium salts, rare-earth metal concentrates, sodium carbonates and sulfates, tungsten concentrate, uranium (1965–66), wollastonite, and values indicated by symbol W..........	XX	117,904	XX	141,449	XX	143,722	XX	150,914
Total..........	XX	1,597,305	XX	r 1,687,822	XX	r 1,693,781	XX	1,808,147

COLORADO

Carbon dioxide, natural ---- thousand cubic feet--	155,668	$26	147,292	$25	182,701	$31	200,657	$34
Clays ---- thousand short tons --	631	1,446	599	1,315	596	1,274	616	1,222
Coal (bituminous) ---- do----	4,790	24,431	5,222	26,075	5,439	25,920	5,558	26,785
Copper (recoverable content of ores, etc.) ---- short tons--	3,828	2,710	4,287	3,065	3,993	3,053	3,451	2,888
Feldspar ---- long tons--	521	3	891	6	300	2	W	W
Gem stones ----	NA	80	NA	80	NA	118	NA	121
Gold (recoverable content of ores, etc.) ---- troy ounces--	37,228	1,303	31,915	1,117	21,181	741	22,638	[5] 889
Gypsum ---- thousand short tons--	100	379	75	269	77	265	98	354
Iron ore (usable) ---- thousand long tons, gross weight--	114	787	164	1,133	W	W	W	W
Lead (recoverable content of ores, etc.) ---- short tons--	22,495	7,018	23,082	6,978	21,923	6,138	19,778	5,226
Lime ---- thousand short tons--	118	2,074	126	2,327	118	2,028	125	2,375
Manganiferous ore (5 to 35 percent Mn) ---- short tons, gross weight--	----------	----------	----------	----------	321	3	----------	----------
Molybdenum (content of concentrate) ---- thousand pounds--	[7] 50,715	[7] 78,609	57,289	88,851	52,040	84,728	61,684	100,296
Natural gas ---- million cubic feet--	126,381	16,303	136,667	17,767	116,857	15,542	121,424	16,392
Natural gas liquids:								
Natural gasoline ---- thousand 42-gallon barrels--	1,290	3,034	1,415	3,565	1,234	3,215	1,289	3,248
LP gases ---- do----	2,176	3,930	1,747	3,596	1,703	3,649	1,987	3,333
Peat ---- short tons--	31,179	236	37,111	278	21,988	204	28,457	250
Petroleum (crude) ---- thousand 42-gallon barrels--	33,511	96,512	33,492	97,462	33,905	99,003	31,937	94,215
Pumice ---- thousand short tons--	56	134	46	104	18	105	28	234
Pyrites ---- thousand long tons--	30	90	W	W	W	W	23	97
Sand and gravel ---- thousand short tons--	20,810	22,041	22,245	23,485	21,810	22,904	23,131	26,608
Silver (recoverable content of ores, etc.) ---- thousand troy ounces--	2,051	2,652	2,085	2,697	1,818	2,817	1,646	3,531
Stone ---- thousand short tons--	4,789	8,638	7,031	11,331	2,992	5,485	2,471	5,201
Tin (content of concentrate) ---- long tons--	32	76	44	99	31	59	33	64
Tungsten concentrate ---- short tons, 60 percent WO_3 basis--	1,176	1,985	1,494	3,626	1,276	3,039	1,893	4,418
Uranium (recoverable content U_3O_8) ---- thousand pounds--	W	W	2,651	21,205	2,537	20,299	2,706	20,009
Vanadium (recoverable in ore and concentrate) ---- short tons--	4,017	14,056	3,697	15,888	3,317	14,260	3,492	12,468
Zinc (recoverable content of ores, etc.) ---- do----	53,870	15,730	54,822	15,898	52,442	14,519	50,258	13,570
Value of items that cannot be disclosed: Beryllium concentrate, cement, fluorspar, scrap mica (1967), perlite, rare-earth metal concentrates (1966–68), salt, and values indicated by symbol W ----	XX	35,867	XX	14,699	XX	16,834	XX	15,630
Total ----	XX	340,150	XX	362,941	XX	346,235	XX	359,458

CONNECTICUT

Clays ---- thousand short tons--	237	$322	192	$296	191	$334	195	$325
Gem stones ----	NA	8	NA	8	NA	8	NA	8
Sand and gravel ---- thousand short tons--	9,940	9,106	9,561	8,963	8,820	8,710	8,752	9,321
Stone ---- do----	5,871	10,444	5,618	10,482	5,097	10,141	6,383	12,729
Value of items that cannot be disclosed: Feldspar, lime, scrap mica, and peat (1965–66) ----	XX	1,354	XX	1,597	XX	1,426	XX	1,493
Total ----	XX	21,234	XX	21,346	XX	20,619	XX	23,876

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
DELAWARE								
Clays thousand short tons	11	$11	11	$11	11	$11	12	$12
Gem stones	NA	1	NA	1	NA	1	NA	1
Sand and gravel thousand short tons	1,545	1,441	1,610	1,443	1,966	1,846	1,596	1,483
Stone do	180	450	210	525	210	525	200	500
Total	XX	1,903	XX	1,980	XX	2,383	XX	1,996
FLORIDA								
Clays thousand short tons	651	$9,752	762	$11,408	756	$11,574	808	$11,699
Lime do	101	1,558	135	1,966	155	2,425	125	2,059
Natural gas million cubic feet	107	14	212	30	123	18	108	16
Peat short tons	19,253	109	11,500	91	22,180	155	41,218	277
Petroleum (crude) thousand 42-gallon barrels	1,464	W	1,799	W	1,568	W	1,474	W
Phosphate rock thousand short tons	21,563	141,258	W	W	W	W	W	W
Sand and gravel do	7,298	6,377	7,403	6,417	6,912	6,479	7,765	7,967
Stone do	35,780	41,148	35,023	38,167	[4] 38,971	[4] 38,723	[4] 36,692	[4] 46,563
Value of items that cannot be disclosed: Cement, kyanite (1968), magnesium compounds, natural gas liquids, rare-earth metal concentrates, staurolite, stone (dimension limestone 1967–68), titanium concentrate, zirconium concentrate, and values indicated by symbol W	XX	49,104	XX	237,368	XX	250,423	XX	236,042
Total	XX	249,320	XX	295,447	XX	309,797	XX	304,623
GEORGIA								
Barite thousand short tons	W	W	W	W	W	W	140	$2,874
Clays do	4,607	$63,158	5,128	$73,685	4,958	$77,814	5,111	88,632
Iron ore (usable) thousand long tons, gross weight	430	2,208	447	2,200	267	1,450	192	1,119
Mica:								
Scrap short tons	13,065	W	16,608	380	17,158	291	W	W
Sheet pounds	2,798	(6)	---------	---------	---------	---------	---------	---------
Sand and gravel thousand short tons	3,675	3,588	3,915	4,185	3,787	4,206	3,808	4,314
Stone do	23,421	48,265	24,690	48,193	23,418	49,953	26,908	56,177
Talc short tons	44,800	313	41,000	255	46,150	292	45,600	288
Value of items that cannot be disclosed: Bauxite, cement, feldspar, kyanite, peat, rare-earth metal concentrates (1966–68), titanium concentrate, zirconium concentrate, and values indicated by symbol W	XX	17,688	XX	19,699	XX	19,952	XX	19,686
Total	XX	135,220	XX	148,597	XX	153,458	XX	173,090

HAWAII								
Cement, thousand 376-pound barrels	1,564	$8,297	1,749	$9,046	1,395	$7,360	1,841	$9,254
Clays, thousand short tons	W	W	W	W	W	W	3	4
Lime, do	9	305	10	320	8	265	8	268
Pumice, do	380	624	374	716	290	562	408	724
Sand and gravel, do	751	2,237	511	1,591	469	1,467	546	1,653
Stone, do	5,172	9,353	5,079	9,482	4,100	7,207	5,211	11,273
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	XX	19	XX	98	XX	75	XX	49
Total	XX	20,835	XX	21,253	XX	16,936	XX	23,225
IDAHO								
Antimony ore and concentrate, short tons, antimony content	818	W	834	W	823	W	853	W
Clays [3], thousand short tons	47	$33	23	$22	19	$16	12	$14
Cobalt, thousand pounds	---------	---------	1	6	---------	---------	---------	-------
Copper (recoverable content of ores, etc.), short tons	5,140	3,639	4,961	3,589	4,210	3,219	3,525	2,950
Gem stones	NA	150	NA	180	NA	180	NA	200
Gold (recoverable content of ores, etc.), troy ounces	5,078	178	5,056	177	4,838	169	3,227	[5] 127
Gypsum, thousand short tons	---------	---------	---------	---------	---------	---------	3	13
Iron ore (usable), thousand long tons, gross weight	9	84	11	97	W	W	W	W
Lead (recoverable content of ores, etc.), short tons	66,606	20,781	72,334	21,867	61,387	17,188	54,790	14,478
Mercury, 76-pound flasks	1,119	639	1,134	501	898	439	W	W
Peat, short tons	W	W	W	W	2,040	16	W	W
Phosphate rock, thousand short tons	W	W	W	W	W	W	3,879	22,721
Pumice, do	46	79	55	107	W	W	135	259
Sand and gravel, do	12,151	13,198	7,544	6,672	11,246	11,490	8,224	9,133
Silver (recoverable content of ores, etc.), thousand troy ounces	18,457	23,865	19,777	25,571	17,033	26,402	15,959	34,225
Stone, thousand short tons	1,831	3,440	2,694	5,415	1,986	4,833	2,195	5,209
Tungsten concentrate, short tons, 60-percent WO_3 basis	---------	---------	2	1	68	175	W	W
Zinc (recoverable content of ores, etc.), short tons	58,034	16,946	60,997	17,689	56,528	15,650	57,248	15,457
Value of items that cannot be disclosed: Cement, clays, (fire clay, bentonite 1965–66, kaolin), abrasive garnet, lime, perlite, titanium concentrate (1965–66), vanadium, and values indicated by symbol W	XX	22,053	XX	32,991	XX	29,631	XX	9,467
Total	XX	105,085	XX	114,885	XX	109,408	XX	114,253
ILLINOIS								
Cement:								
Portland, thousand 376-pound barrels	9,358	$30,622	9,203	$28,617	9,069	$30,186	9,372	$32,475
Masonry, thousand 280-pound barrels	615	1,907	614	1,868	591	1,851	602	2,097
Clays [3], thousand short tons	2,169	4,601	1,894	3,996	1,881	3,799	2,327	4,813
Coal (bituminous), do	58,483	218,972	63,571	244,837	65,133	252,975	62,441	250,685
Fluorspar, short tons	159,140	7,861	176,175	8,002	210,207	9,859	188,325	9,134

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
ILLINOIS—Continued								
Lead (recoverable content of ores, etc.)......short tons..	3,005	$938	2,285	$691	2,384	$668	1,467	$388
Natural gas......million cubic feet..	7,396	865	7,230	860	5,144	602	4,380	552
Peat......short tons..	36,774	453	44,374	565	49,716	697	61,520	867
Petroleum (crude)......thousand 42-gallon barrels..	63,708	186,664	[r] 61,661	[r] 184,983	[3] 60,115	[3] 181,581	56,391	173,120
Sand and gravel......thousand short tons..	36,228	40,480	38,237	43,201	38,801	44,175	45,609	52,943
Stone......do....	47,066	61,294	46,157	60,961	48,458	66,757	55,858	80,188
Zinc (recoverable content of ores, etc.)......short tons..	18,314	5,348	15,192	4,406	20,416	5,652	18,182	4,909
Value of items that cannot be disclosed: Clay (fuller's earth), gem stones, lime, natural gas liquids, and tripoli......	XX	33,020	XX	34,362	XX	37,999	XX	35,372
Total......	XX	593,025	XX	[r] 617,349	XX	636,801	XX	647,543
INDIANA								
Abrasive stones......short tons..	5	$15	5	$15	5	$16	5	$16
Cement [2]......thousand 376-pound barrels..	14,925	48,797	15,305	49,826	15,924	53,123	14,774	48,096
Clays......thousand short tons..	1,459	2,160	1,491	2,196	1,489	2,126	1,550	2,355
Coal (bituminous)......do....	15,565	59,927	17,326	67,857	18,772	73,419	18,486	71,680
Natural gas......million cubic feet..	239	56	215	51	198	46	234	55
Peat......short tons..	53,873	511	38,111	456	42,962	441	38,763	557
Petroleum (crude)......thousand 42-gallon barrels..	11,481	32,606	10,617	31,850	10,081	30,041	8,692	26,511
Sand and gravel......thousand short tons..	24,867	22,220	24,992	23,542	26,265	25,588	25,774	26,160
Stone......do....	24,574	42,124	24,323	42,474	26,977	46,725	26,307	46,790
Value of items that cannot be disclosed: Cement (masonry), gypsum, and lime (1966–68)......	XX	10,299	XX	11,743	XX	13,396	XX	13,166
Total......	XX	218,715	XX	230,010	XX	244,921	XX	235,386
IOWA								
Cement:								
Portland......thousand 376-pound barrels..	13,643	$46,273	14,058	$46,736	13,712	$45,394	13,900	$47,275
Masonry......thousand 280-pound barrels..	608	1,867	683	1,890	612	1,853	624	1,986
Clays......thousand short tons..	1,085	1,347	1,130	1,438	1,208	1,643	1,264	1,747
Coal (bituminous)......do....	1,043	3,694	1,025	3,783	883	3,227	876	3,289
Gypsum......do....	1,254	5,554	1,285	5,577	1,219	5,186	1,351	5,838
Sand and gravel......do....	18,205	17,152	19,644	18,213	17,784	16,564	16,332	15,192
Stone......do....	25,891	35,468	27,729	40,081	26,133	37,912	26,150	40,397
Value of items that cannot be disclosed: Gem stones, lime, and peat...	XX	1,428	XX	1,595	XX	1,443	XX	1,573
Total......	XX	112,783	XX	119,313	XX	113,222	XX	117,297

KANSAS								
Cement:[2]								
Portland ______ thousand 376-pound barrels	8,801	$26,972	8,979	$27,246	8,833	$25,545	9,680	$29,898
Masonry ______ thousand 280-pound barrels	404	1,178	395	1,151	350	1,000	383	1,177
Clays ______ thousand short tons	789	953	847	1,006	935	1,339	932	1,433
Coal (bituminous) ______ do	1,310	6,072	1,122	5,355	1,136	5,294	1,268	6,526
Helium: Crude ______ thousand cubic feet	2,551,026	29,518	2,624,200	30,951	2,719,700	32,554	2,749,700	33,600
Grade A ______ do	19,763	904	75,500	1,885	225,000	5,364	291,700	7,300
Lead (recoverable content of ores, etc.) ______ short tons	1,644	513	1,109	335	1,031	289	1,227	324
Natural gas ______ million cubic feet	793,379	105,519	847,495	114,412	871,971	116,844	835,555	115,307
Natural gas liquids:								
Natural gasoline ______ thousand 42-gallon barrels	3,654	7,791	4,168	9,399	4,623	10,703	4,824	10,977
LP gases ______ do	13,986	22,322	15,813	25,902	15,835	31,923	15,728	25,827
Petroleum (crude) ______ do	104,733	305,820	103,738	306,027	99,200	297,600	94,505	285,405
Pumice ______ thousand short tons	W	W	W	W	W	W	11	10
Salt [9] ______ do	1,053	12,376	969	13,388	1,069	14,686	1,128	15,520
Sand and gravel ______ do	12,544	8,473	11,627	8,374	12,066	8,350	12,427	10,559
Stone ______ do	15,270	20,538	14,027	18,789	13,551	17,806	14,402	20,714
Zinc (recoverable content of ores, etc.) ______ short tons	6,508	1,900	4,769	1,383	4,765	1,319	3,012	813
Value of items that cannot be disclosed: Natural cement, gypsum, lime (1968), salt (brine), and values indicated by symbol W ______	XX	2,642	XX	2,789	XX	3,152	XX	3,311
Total ______	XX	553,491	XX	568,392	XX	574,068	XX	568,701
KENTUCKY								
Clays [3] ______ thousand short tons	1,059	$2,580	1,152	$2,277	1,195	$2,066	1,219	$1,952
Coal (bituminous) ______ do	85,766	324,523	93,156	363,440	100,294	396,883	101,156	395,039
Fluorspar ______ short tons	31,992	1,485	28,725	1,361	32,952	1,686	17,050	878
Lead (recoverable content of ores, etc.) ______ do	756	236	484	146	845	237	W	W
Natural gas ______ million cubic feet	78,976	18,638	76,536	18,139	89,168	21,400	89,024	22,256
Petroleum (crude) ______ thousand 42-gallon barrels	19,386	55,638	18,066	51,488	15,535	45,052	14,036	41,125
Sand and gravel ______ thousand short tons	6,742	6,332	8,064	7,524	7,981	7,859	7,478	8,081
Silver (recoverable content of ores, etc.) ______ thousand troy ounces	2	2	1	1	1	1	---------	---------
Stone ______ thousand short tons	26,029	34,533	22,667	31,179	24,812	35,481	30,105	43,266
Zinc (recoverable content of ores, etc.) ______ short tons	5,654	1,651	6,586	1,910	6,317	1,749	W	W
Value of items that cannot be disclosed: Native asphalt (1966–68), cement, ball clay, natural gas liquids, and values indicated by symbol W ______	XX	20,763	XX	20,899	XX	23,291	XX	22,266
Total ______	XX	466,381	XX	498,364	XX	535,705	XX	534,863
LOUISIANA								
Clays ______ thousand short tons	909	$936	1,005	$983	995	$1,260	863	$1,163
Lime ______ do	842	9,980	835	9,274	758	9,891	781	10,159
Natural gas ______ million cubic feet	4,466,786	812,955	5,081,435	929,902	5,716,857	1,057,619	6,416,015	1,212,627

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
LOUISIANA—Continued								
Natural gas liquids:								
Natural gasoline and cycle products..thousand 42-gallon barrels..	34,091	$102,731	37,192	$113,802	41,777	$130,212	49,928	$156,903
LP gases ..do....	30,953	46,101	34,993	72,016	43,921	92,234	57,165	91,464
Petroleum (crude) ..do....	594,853	1,841,714	674,318	2,097,129	774,527	2,419,823	817,426	2,570,641
Salt ..thousand short tons..	8,126	41,812	8,736	44,189	9,585	48,483	10,908	53,854
Sand and gravel ..do....	14,298	16,405	18,216	22,504	20,312	27,442	20,411	26,504
Stone [4] ..do....	7,452	10,905	8,091	11,253	7,599	11,174	9,387	11,785
Sulfur (Frasch process) ..thousand long tons..	3,577	81,372	4,018	104,472	4,233	139,739	4,074	162,664
Value of items that cannot be disclosed: Cement, gypsum, and stone (crushed miscellaneous)	XX	23,350	XX	24,616	XX	23,873	XX	23,246
Total	XX	2,988,261	XX	3,430,140	XX	3,961,750	XX	4,321,010
MAINE								
Clays ..thousand short tons..	49	$63	45	$58	42	$54	[3] 42	[3] $65
Gem stones	NA	35	NA	35	NA	35	NA	35
Peat ..short tons..	1,275	56	1,600	60	W	W	W	W
Sand and gravel ..thousand short tons..	17,294	7,831	15,036	7,027	11,627	5,368	11,866	5,978
Stone ..do....	1,100	3,409	1,092	3,622	1,159	2,999	1,187	3,205
Value of items that cannot be disclosed: Cement, fire clay (1968), copper (1968), feldspar, silver (1968), zinc (1968), and values indicated by symbol W	XX	6,347	XX	5,932	XX	6,426	XX	8,527
Total	XX	17,741	XX	16,734	XX	14,882	XX	17,810
MARYLAND								
Clays ..thousand short tons..	[3] 914	[3] $1,088	[3] 856	[3] $1,084	998	$1,462	[3] 1,078	[3] $1,252
Coal (bituminous) ..do....	1,210	4,389	1,222	4,367	1,305	4,548	1,447	5,318
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime ..thousand short tons..	37	481	29	386	W	W	W	W
Natural gas ..million cubic feet..	408	103	696	181	621	159	864	221
Peat ..short tons..	W	W	W	W	W	W	5,554	94
Sand and gravel ..thousand short tons..	16,200	21,188	15,108	20,383	12,868	17,724	11,719	17,157
Stone ..do....	14,553	28,432	13,868	27,229	14,479	28,581	13,344	26,606
Value of items that cannot be disclosed: Cement, clays (ball clay 1965–66, 1968, fireclay 1968), greensand marl, potassium salts, talc and soapstone, and values indicated by symbol W	XX	22,311	XX	20,528	XX	20,342	XX	21,193
Total	XX	77,995	XX	74,161	XX	72,819	XX	71,844

MASSACHUSETTS								
Clays thousand short tons	181	$238	202	$260	W	W	257	$314
Gem stones	NA	2	NA	2	NA	$2	NA	2
Lime thousand short tons	170	2,779	182	2,712	195	3,044	198	3,380
Sand and gravel do	22,141	16,172	17,321	17,846	17,881	19,504	17,799	20,106
Stone do	6,168	16,980	6,424	17,624	6,203	17,724	6,917	19,501
Value of items that cannot be disclosed: Nonmetals and value indicated by symbol W	XX	27	XX	29	XX	338	XX	37
Total	XX	36,198	XX	38,473	XX	40,612	XX	43,340
MICHIGAN								
Cement:								
Portland thousand 376-pound barrels	27,565	$86,996	28,171	$87,413	29,645	$94,515	31,375	$99,158
Masonry thousand 280-pound barrels	2,108	5,373	2,032	5,221	1,995	5,296	2,006	5,527
Clays thousand short tons	2,402	2,580	2,450	2,620	2,466	2,636	2,599	2,906
Copper (recoverable content of ores, etc.) short tons	71,749	50,798	73,449	53,133	58,458	44,692	74,805	62,607
Gypsum thousand short tons	1,338	5,027	1,522	5,489	1,422	5,085	1,405	5,196
Iron ore (usable) thousand long tons, gross weight	13,527	145,482	14,377	157,377	14,130	162,610	12,699	148,890
Lime thousand short tons	1,095	13,057	1,701	20,016	1,787	21,582	1,630	19,870
Magnesium compounds from sea water and brine (except for metal) short tons, MgO equivalent	319,389	26,143	342,482	28,105	309,446	26,388	266,406	25,087
Natural gas million cubic feet	34,558	8,674	34,120	8,598	33,589	8,296	40,480	10,160
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	216	607	374	1,099	1,139	3,491	1,066	3,177
LP gases do	1,817	3,815	1,898	4,385	1,414	3,444	1,384	3,432
Peat short tons	230,950	2,134	235,842	2,175	237,107	2,292	237,513	2,919
Petroleum (crude) thousand 42-gallon barrels	14,728	41,091	14,273	40,913	13,664	39,455	12,974	38,287
Salt thousand short tons	4,171	36,087	4,465	38,611	4,789	42,389	4,893	44,481
Sand and gravel do	53,168	47,176	55,123	49,521	52,310	49,616	56,663	54,979
Silver (recoverable content of ores, etc.) thousand troy ounces	458	592	483	625	302	468	473	1,014
Stone thousand short tons	34,713	36,438	37,864	40,380	36,432	39,910	37,279	41,092
Value of items that cannot be disclosed: Bromine, calcium-magnesium chloride, gem stones, iodine, and potassium salts	XX	53,490	XX	56,446	XX	58,039	XX	58,293
Total	XX	565,560	XX	602,127	XX	610,204	XX	627,075
MINNESOTA								
Clays [3] thousand short tons	207	$311	224	$336	228	$342	240	$359
Iron ore (usable) thousand long tons, gross weight	50,873	459,290	55,133	499,388	49,457	468,623	51,275	508,814
Manganiferous ore (5 to 35 percent Mn) short tons, gross weight	280,705	W	275,581	W	236,753	W	191,846	W
Peat short tons	7,346	123	11,366	197	13,968	257	6,400	96
Sand and gravel thousand short tons	37,545	27,296	39,331	28,972	41,212	33,182	44,674	36,414
Stone do	4,371	11,680	4,901	11,688	4,160	11,442	4,427	13,045

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
MINNESOTA—Continued								
Value of items that cannot be disclosed: Abrasive stones, cement, fire clay, gem stones, lime, and values indicated by symbol W	XX	$9,060	XX	$9,696	XX	$9,530	XX	$8,699
Total	XX	507,760	XX	550,277	XX	523,326	XX	567,427
MISSISSIPPI								
Clays ... thousand short tons	1,502	$6,997	1,727	$7,489	1,654	$7,852	1,693	$9,075
Natural gas ... million cubic feet	166,825	28,861	156,652	27,257	139,497	24,133	135,051	22,601
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	633	1,606	566	1,483	427	1,167	459	1,277
LP gases ... do	527	975	443	987	424	1,085	518	958
Petroleum (crude) ... do	56,183	148,437	55,227	146,353	57,147	155,726	58,708	164,396
Sand and gravel ... thousand short tons	8,447	8,717	12,675	13,563	14,039	15,485	11,980	12,669
Stone ... do	[4] 2,357	[4] 2,358	[4] 1,532	[4] 1,641	1,879	2,055	747	833
Value of items that cannot be disclosed: Cement, iron ore (1965–67), lime, magnesium compounds, and stone (dimension sandstone 1965–66)	XX	12,082	XX	12,587	XX	r 9,055	XX	9,146
Total	XX	210,033	XX	211,360	XX	r 216,558	XX	220,955
MISSOURI								
Barite ... thousand short tons	329	$4,219	337	$4,280	332	$4,444	284	$4,102
Cement:								
Portland ... thousand 376-pound barrels	13,334	46,034	13,848	46,228	15,044	52,119	20,081	71,206
Masonry ... thousand 280-pound barrels	377	1,173	382	1,075	372	1,172	405	1,312
Clays ... thousand short tons	2,226	5,439	2,329	5,989	2,805	6,220	2,433	6,158
Coal (bituminous) ... do	3,564	14,779	3,582	14,834	3,696	15,573	3,205	13,460
Copper (recoverable content of ores, etc.) ... short tons	2,331	1,650	3,913	2,831	3,215	2,458	5,494	4,598
Iron ore (usable) ... thousand long tons, gross weight	1,784	24,607	1,887	26,450	1,871	26,673	1,648	23,585
Lead (recoverable content of ores, etc.) ... short tons	133,521	41,659	132,255	39,981	152,649	42,742	212,611	56,180
Lime ... thousand short tons	1,442	16,782	1,494	17,910	W	W	W	W
Natural gas ... million cubic feet	84	21	---------	---------	121	30	14	4
Petroleum (crude) ... thousand 42-gallon barrels	73	W	97	W	W	W	W	W
Sand and gravel ... thousand short tons	12,068	13,735	10,702	13,540	9,716	12,556	10,649	14,204
Silver (recoverable content of ores, etc.) ... thousand troy ounces	300	387	---------	---------	226	351	341	731
Stone ... thousand short tons	36,247	53,574	35,240	53,393	36,585	53,953	38,763	58,522

Zinc (recoverable content of ores, etc.) short tons	4,312	1,259	3,968	1,151	7,430	2,057	12,301	3,321
Value of items that cannot be disclosed: Native asphalt, tripoli (1965), and values indicated by symbol W	XX	250	XX	288	XX	r 16,662	XX	18,572
Total	XX	225,568	XX	227,950	XX	r 237,010	XX	275,955
MONTANA								
Clays [3] thousand short tons	76	$98	53	$56	46	$50	30	$34
Coal (bituminous and lignite) do	364	1,050	419	1,290	371	996	519	1,214
Copper (recoverable content of ores, etc.) short tons	115,489	81,766	128,061	92,639	65,483	50,063	69,480	58,151
Gem stones	NA	77	NA	109	NA	109	NA	109
Gold (recoverable content of ores, etc.) troy ounces	22,772	797	25,009	875	9,786	343	13,385	[5] 525
Iron ore (usable) thousand long tons, gross weight	9	71	12	93	10	81	12	W
Lead (recoverable content of ores, etc.) short tons	6,981	2,178	4,409	1,333	898	251	1,870	494
Lime thousand short tons	159	1,512	225	2,116	143	1,765	179	2,005
Manganese ore (35 percent or more Mn) short tons, gross weight	23,621	W	W	W	W	W	4,649	213
Manganiferous ore (5 to 35 percent Mn) do	1,968	W	1,755	28	2,763	16	2,063	22
Natural gas million cubic feet	28,105	2,305	30,685	2,547	25,866	2,173	19,313	1,757
Petroleum (crude) thousand 42-gallon barrels	32,778	79,624	35,380	86,273	34,959	87,543	48,460	124,488
Pumice thousand short tons	---------	---------	22	5	---------	---------	93	327
Sand and gravel do	12,048	13,587	13,816	13,523	12,339	10,655	8,762	7,754
Silver (recoverable content of ores, etc.) thousand troy ounces	5,207	6,733	5,320	6,878	2,066	3,203	2,133	4,574
Stone thousand short tons	5,512	5,971	4,150	5,212	4,782	6,037	3,314	4,878
Zinc (recoverable content of ores, etc.) short tons	33,786	9,866	29,120	8,445	3,341	925	3,778	1,020
Value of items that cannot be disclosed: Antimony (1966–67), barite (1965–66), cement, clays (bentonite), fluorspar, gypsum, natural gas liquids, peat, phosphate rock, talc, tungsten (1966–68), uranium ore (1966), vermiculite, and values indicated by symbol W	XX	22,528	XX	23,846	XX	22,314	XX	20,566
Total	XX	228,163	XX	245,268	XX	186,524	XX	228,131
NEBRASKA								
Clays thousand short tons	141	$141	153	$153	126	$142	148	$206
Gem stones	NA	5	NA	5	NA	5	NA	4
Lime thousand short tons	W	W	W	W	W	W	28	W
Natural gas million cubic feet	10,720	1,565	10,196	1,621	8,453	1,454	8,129	1,423
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	186	516	219	653	186	578	153	456
LP gases do	403	847	468	1,141	494	1,223	451	911
Petroleum (crude) do	17,216	45,796	13,850	37,673	13,373	36,775	13,183	36,781
Sand and gravel thousand short tons	11,993	13,697	13,539	14,179	11,739	10,878	13,013	13,175
Stone do	4,198	6,637	5,055	7,916	4,846	7,483	4,416	7,435
Value of items that cannot be disclosed: Cement, pumice, and values indicated by symbol W	XX	14,622	XX	15,180	XX	12,330	XX	14,446
Total	XX	83,826	XX	78,521	XX	70,868	XX	74,837

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
NEVADA								
Antimony ore and concentrate……short tons, antimony content	26	$19	68	$63	53	$35	------	------
Barite……thousand short tons	91	583	139	933	154	923	216	$1,511
Copper (recoverable content of ores, etc.)……short tons	71,332	50,503	78,720	56,946	50,771	38,815	77,213	64,623
Gem stones	NA	100	NA	100	NA	100	NA	100
Gold (recoverable content of ores, etc.)……troy ounces	229,050	8,017	366,903	12,842	434,993	15,225	317,382	[5] 12,460
Gypsum……thousand short tons	710	2,518	594	2,023	409	1,412	552	1,534
Iron ore (usable)……thousand long tons, gross weight	1,141	5,330	1,000	4,931	641	2,858	569	2,917
Lead (recoverable content of ores, etc.)……short tons	2,277	710	3,581	1,083	1,500	420	868	228
Mercury……76-pound flasks	3,333	1,902	3,355	1,482	4,703	2,301	4,780	2,560
Perlite……short tons	13,780	121	W	W	10,712	94	9,315	79
Petroleum (crude)……thousand 42-gallon barrels	209	W	307	W	279	W	271	W
Pumice……thousand short tons	68	187	55	190	105	236	62	144
Sand and gravel……do	9,455	11,796	9,085	9,134	10,166	8,644	7,812	10,442
Silver (recoverable content of ores, etc.)……thousand troy ounces	507	656	867	1,122	566	877	645	1,384
Stone……thousand short tons	1,248	2,247	2,002	2,519	1,375	2,145	1,325	2,041
Sulfur ore……long tons	336	6	------	------	------	------	------	------
Talc and soapstone……short tons	3,592	31	4,715	24	2,096	17	3,029	38
Tungsten ore and concentrate……short tons, 60 percent WO_3 basis	W	W	W	W	W	W	25	58
Zinc (recoverable content of ores, etc.)……short tons	3,858	1,127	5,827	1,690	3,035	840	2,104	568
Value of items that cannot be disclosed: Brucite, cement, clays, diatomite, fluorspar, lime, lithium minerals (1966–68), magnesite, molybdenum, peat (1965–67), salt, uranium (1965–66), and values indicated by symbol W	XX	14,142	XX	17,555	XX	15,941	XX	19,354
Total	XX	99,995	XX	112,637	XX	90,883	XX	120,041
NEW HAMPSHIRE								
Clays……thousand short tons	53	$47	51	$51	42	$42	41	$41
Mica, sheet……pounds	------	------	------	------	16,000	W	------	------
Peat……short tons	------	------	175	2	50	(6)	------	------
Sand and gravel……thousand short tons	10,584	5,559	7,626	4,807	8,449	5,137	7,742	5,698
Stone……do	153	1,932	206	2,091	473	2,887	383	3,377
Value of items that cannot be disclosed: Other nonmetals	XX	127	XX	49	XX	51	XX	50
Total	XX	7,665	XX	7,000	XX	8,117	XX	9,166
NEW JERSEY								
Clays……thousand short tons	506	$1,388	488	$1,319	437	$1,189	378	$1,008

Gem stones	NA	10	NA	10	NA	10	NA	10
Peat .... short tons	40,480	431	36,312	489	43,045	542	55,786	621
Sand and gravel .... thousand short tons	17,389	28,646	17,782	29,322	18,626	29,975	20,306	33,570
Stone .... do	12,232	27,247	12,453	28,056	12,611	28,253	13,151	30,843
Zinc (recoverable content of ores, etc.)[10] .... short tons	38,297	11,106	25,287	7,319	26,041	7,031	25,668	6,930
Value of items that cannot be disclosed: Iron ore (1965–67), lime, magnesium compounds, manganiferous residuum, greensand marl, and titanium concentrate	XX	11,330	XX	9,080	XX	5,747	XX	4,984
Total	XX	80,158	XX	75,595	XX	72,747	XX	77,466

NEW MEXICO

Barite .... thousand short tons	(6)	$2	---------	---------	---------	---------	---------	---------
Carbon dioxide, natural .... thousand cubic feet	833,819	62	795,885	$58	771,516	$57	749,364	$52
Clays .... thousand short tons	60	101	W	W	46	74	66	89
Coal (bituminous) .... do	3,212	10,710	2,755	9,110	3,463	12,641	3,429	13,507
Copper (recoverable content of ores, etc.) .... short tons	98,658	69,850	108,614	78,571	75,008	57,345	90,769	75,968
Feldspar .... long tons	---------	---------	---------	---------	---------	---------	98	W
Gem stones	NA	45	NA	45	NA	60	NA	59
Gold (recoverable content of ores, etc.) .... troy ounces	9,641	337	9,295	325	5,188	182	6,630	[5] 260
Gypsum .... thousand short tons	W	W	146	545	155	588	146	549
Helium, grade A .... thousand cubic feet	80,583	2,821	95,900	3,357	71,200	2,492	39,100	1,355
Iron ore (usable) .... thousand long tons, gross weight	W	W	W	W	W	W	17	113
Lead (recoverable content of ores, etc.) .... short tons	3,387	1,057	1,596	482	1,827	512	1,363	360
Lime .... thousand short tons	33	465	34	472	17	243	27	377
Manganese ore (35 percent or more Mn) .... short tons, gross weight	5,637	156	W	W	W	W	6,729	W
Manganiferous ore (5 to 35 percent Mn) .... do	50,090	328	47,590	324	49,323	348	50,681	379
Mica: Scrap .... short tons	4,263	45	W	W	W	W	W	W
Natural gas .... million cubic feet	937,205	110,590	998,076	124,760	1,067,510	138,776	1,164,182	156,000
Natural gas liquids:								
Natural gasoline and cyde products .... thousand 42-gallon barrels	8,535	20,824	8,065	19,736	8,050	20,730	8,868	23,104
LP gases .... do	18,079	25,817	19,433	31,832	21,647	40,003	23,802	34,989
Peat .... short tons	---------	---------	---------	---------	---------	---------	446	4
Perlite .... do	331,011	2,905	348,334	3,423	346,586	3,424	365,481	3,706
Petroleum (crude) .... thousand 42-gallon barrels	119,166	334,977	124,154	352,101	126,144	368,340	128,550	378,708
Potassium salts .... thousand short tons, K_2O equivalent	2,848	117,771	2,953	108,653	2,883	91,098	2,289	63,406
Pumice .... thousand short tons	264	915	245	787	220	639	243	527
Salt .... do	64	572	66	716	82	1,036	W	W
Sand and gravel .... do	11,763	12,130	15,503	13,029	14,672	14,336	12,262	12,396
Silver (recoverable content of ores, etc.) .... thousand troy ounces	288	372	243	314	157	244	225	482
Stone .... thousand short tons	1,911	3,020	2,652	4,056	1,391	2,403	2,226	3,527
Uranium (recoverable content U_3O_8) .... thousand pounds	W	W	9,340	74,721	11,202	89,615	12,282	95,144
Vanadium (recoverable in ore and concentrate) .... short tons	W	221	W	53	W	W	W	W
Zinc (recoverable content of ores, etc.) .... do	36,460	10,646	29,296	8,496	21,380	5,919	18,686	5,045
Value of items that cannot be disclosed: Beryllium (1968), cement, fluorspar (1967–68), molybdenum, tin (1965–66), and values indicated by symbol W	XX	79,936	XX	20,328	XX	23,001	XX	23,669
Total	XX	806,675	XX	856,294	XX	874,106	XX	893,775

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965 Quantity	1965 Value (thousands)	1966 Quantity	1966 Value (thousands)	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)
NEW YORK								
Clays .... thousand short tons..	1,354	$1,717	1,464	$1,726	1,506	$1,814	1,675	$1,790
Emery .... short tons..	10,720	204	11,102	210	W	W	W	W
Gem stones	NA	10	NA	10	NA	10	NA	10
Gypsum .... thousand short tons..	662	3,511	559	2,998	570	3,118	570	2,925
Lead (recoverable content of ores, etc.) .... short tons..	601	188	1,097	332	1,653	463	1,396	369
Lime .... thousand short tons..	W	W	1,096	9,870	1,139	10,570	1,086	10,154
Natural gas .... million cubic feet..	3,340	1,029	2,699	837	3,837	1,201	4,632	1,390
Peat .... short tons..	25,098	232	27,211	250	23,053	232	14,888	153
Petroleum (crude) .... thousand 42-gallon barrels..	1,632	7,246	1,735	7,925	1,972	9,026	1,532	7,093
Salt .... thousand short tons..	5,002	35,771	4,980	36,203	5,320	41,568	5,218	42,488
Sand and gravel .... do....	39,225	40,370	41,903	43,091	43,500	44,499	43,439	45,812
Silver (recoverable content of ores, etc.) .... thousand troy ounces..	11	15	22	28	31	48	28	59
Stone .... thousand short tons..	30,801	48,675	34,130	54,543	33,389	56,615	35,441	63,510
Zinc (recoverable content of ores, etc.) .... short tons..	69,880	20,405	73,454	21,302	70,555	19,534	66,194	17,872
Value of items that cannot be disclosed: Cement, abrasive garnet, iron ore, talc, titanium concentrate, wollastonite, and values indicated by symbol W	XX	130,684	XX	121,482	XX	110,620	XX	106,011
Total	XX	290,057	XX	300,807	XX	299,318	XX	299,636
NORTH CAROLINA								
Barite .... thousand short tons..	---------	---------	---------	---------	1	$6	W	W
Clays[3] .... do....	3,383	$2,162	3,381	$2,241	2,977	2,012	3,310	$2,148
Feldspar .... long tons..	278,990	3,153	301,610	3,157	265,690	8,113	316,862	4,340
Gem stones	NA	15	NA	15	NA	25	NA	20
Mica:								
Scrap .... short tons..	72,199	1,987	63,480	2,348	69,639	1,751	69,054	1,640
Sheet .... pounds..	713,293	185	4,500	1	4,500	W	15,000	W
Sand and gravel .... thousand short tons..	10,499	10,076	11,601	11,132	10,014	9,962	10,771	11,178
Stone .... do....	[4] 18,835	[4] 30,920	[4] 22,377	[4] 36,136	24,507	41,488	24,543	42,429
Talc and pyrophyllite .... short tons..	109,721	556	113,866	576	109,398	513	100,030	520
Value of items that cannot be disclosed: Asbestos, cement, clay (kaolin), lithium minerals, olivine, phosphate rock (1966–68), stone (crushed and dimension marble 1965–66, and dimension slate 1965–66), and values indicated by symbol W	XX	11,329	XX	16,272	XX	18,224	XX	20,544
Total	XX	60,888	XX	71,878	XX	77,094	XX	82,819

NORTH DAKOTA								
Clays thousand short tons	81	$114	76	$100	W	W	W	W
Coal (lignite) do	2,732	5,848	3,543	6,976	4,156	$7,967	4,487	$7,986
Gem stones	NA	1	NA	1	NA	1	NA	1
Natural gas million cubic feet	35,652	5,704	46,585	7,547	40,462	6,636	41,023	6,769
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	501	1,263	552	1,415	554	1,443	558	1,479
LP gases do	2,028	3,066	2,188	3,859	2,111	3,901	2,156	3,622
Petroleum (crude) do	26,350	65,875	27,126	69,170	25,315	65,818	25,040	66,106
Sand and gravel thousand short tons	7,574	7,895	10,145	10,568	8,822	9,118	10,839	10,159
Stone do	356	624	170	305	596	1,092	165	326
Value of items that cannot be disclosed: Lime, molybdenum (1965–67), peat, salt, uranium, vanadium (1965), and values indicated by symbol W	XX	3,403	XX	2,327	XX	1,562	XX	1,588
Total	XX	93,793	XX	102,268	XX	97,538	XX	98,036
OHIO								
Cement:								
Portland thousand 376-pound barrels	14,786	$47,499	15,181	$48,740	14,726	$46,860	15,222	$49,814
Masonry thousand 280-pound barrels	1,050	3,004	976	2,785	946	2,730	1,063	3,155
Clays thousand short tons	5,070	14,816	5,089	14,522	4,670	15,185	4,750	15,216
Coal (bituminous) do	39,390	146,028	43,341	164,444	46,014	176,921	48,323	191,427
Gem stones	NA	3	NA	3	NA	3	NA	3
Lime thousand short tons	3,831	53,208	3,858	50,997	3,636	48,817	3,701	49,367
Natural gas million cubic feet	35,684	8,421	43,133	10,223	41,315	9,957	42,673	10,540
Peat short tons	5,352	80	5,214	84	7,301	100	6,506	94
Petroleum (crude) thousand 42-gallon barrels	12,908	37,940	10,899	32,700	9,924	31,427	11,204	35,722
Salt thousand short tons	5,026	34,816	5,138	35,735	5,407	39,549	5,713	43,172
Sand and gravel do	40,852	49,305	43,851	52,909	43,196	52,888	46,734	57,671
Stone do	42,263	66,969	45,002	72,900	45,458	72,534	[4] 48,057	[4] 78,830
Value of items that cannot be disclosed: Abrasive stone, gypsum, stone (dimension limestone 1968)	XX	2,163	XX	1,998	XX	1,917	XX	1,887
Total	XX	464,252	XX	488,040	XX	498,888	XX	536,898
OKLAHOMA								
Clays [3] thousand short tons	794	$806	745	$754	744	$869	726	$967
Coal (bituminous) do	974	5,520	843	4,935	823	4,703	1,089	6,401
Gypsum do	761	2,343	785	2,212	804	2,266	931	2,565
Helium, grade A thousand cubic feet	310,700	10,874	352,400	12,333	309,100	9,835	308,600	8,700
Lead (recoverable content of ores, etc.) short tons	2,813	878	2,999	907	2,727	764	2,387	631
Natural gas million cubic feet	1,320,995	182,297	1,351,225	189,172	1,412,952	202,052	1,390,884	197,506
Natural gas liquids:								
Natural gasoline and cycle products thousand 42-gallon barrels	13,575	34,561	13,717	35,715	13,545	35,846	13,905	38,829
LP gases do	21,302	32,208	23,482	44,381	23,944	49,276	25,497	39,520

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
OKLAHOMA—Continued								
Petroleum (crude) thousand 42-gallon barrels	203,441	$587,944	224,839	$654,281	230,749	$676,095	223,623	$668,202
Salt thousand short tons	9	65	W	W	10	76	7	44
Sand and gravel do	5,218	6,023	6,040	7,565	4,540	5,280	5,041	6,288
Stone do	16,417	18,071	15,334	17,398	16,355	18,932	17,290	21,950
Zinc (recoverable content of ores, etc.) short tons	12,715	3,713	11,237	3,259	10,670	2,954	6,921	1,869
Value of items that cannot be disclosed: Cement, clay (bentonite), copper, lime, pumice, silver, tripoli, and values indicated by symbol W	XX	23,953	XX	24,484	XX	23,178	XX	23,360
Total	XX	909,256	XX	997,391	XX	1,032,126	XX	1,016,832
OREGON								
Clays thousand short tons	291	$359	361	$362	[3] 295	[3] $295	[3] 213	[3] $284
Diatomite short tons	W	W	W	W	108	2	120	W
Gem stones	NA	750	NA	750	NA	750	NA	750
Gold (recoverable content of ores, etc.) troy ounces	499	17	281	10	186	7	23	[5] 1
Lime thousand short tons	98	1,853	116	2,283	99	2,059	120	2,407
Mercury 76-pound flasks	1,364	779	700	309	943	461	938	502
Nickel (content of ore and concentrate) short tons	16,188	W	15,036	W	15,287	W	17,294	W
Peat do	---------	---------	900	17	W	W	360	11
Perlite do	---------	---------	W	W	8	(6)	---------	---------
Pumice thousand short tons	657	1,181	714	1,256	834	1,195	725	977
Sand and gravel do	21,800	32,849	35,327	34,986	19,630	25,250	18,260	21,457
Silver (recoverable content of ores, etc.) thousand troy ounces	9	11	(6)	(6)	(6)	(6)	(6)	1
Stone thousand short tons	21,212	27,301	33,288	48,335	13,201	20,256	14,312	21,168
Talc and soapstone short tons	---------	---------	---------	---------	W	W	3	1
Value of items that cannot be disclosed: Cement, clay (fire clay 1967–68), copper (1965–66, 1968), iron ore (pigment material 1965–66), lead (1965, 1968), zinc (1965), and values indicated by symbol W	XX	17,866	XX	19,176	XX	16,285	XX	16,890
Total	XX	82,966	XX	107,484	XX	66,560	XX	64,449
PENNSYLVANIA								
Cement:								
Portland thousand 376-pound barrels	40,153	$116,925	40,004	$114,357	40,197	$114,592	43,018	$123,176
Masonry thousand 280-pound barrels	3,006	7,991	2,960	7,860	2,929	7,948	3,151	8,706
Clays [3] thousand short tons	3,394	17,697	3,293	17,033	2,994	16,703	3,034	17,679
Coal:								
Anthracite do	14,866	122,021	12,941	100,663	12,256	96,160	11,461	97,245
Bituminous do	80,308	407,267	81,448	425,168	79,412	419,845	[illegible]	[illegible]

Copper (recoverable content of ores, etc.) short tons	4,354	3,083	3,178	2,299	4,401	3,365	4,850	4,059
Gem stones	NA	4	NA	4	NA	4	NA	4
Lime thousand short tons	1,568	22,496	1,585	22,816	1,719	24,715	1,702	24,272
Natural gas million cubic feet	84,461	22,551	90,914	25,820	89,966	25,280	87,987	24,460
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	24	55	76	186	28	77	27	73
LP gases do	40	109	44	121	42	114	37	95
Peat short tons	45,600	527	52,912	562	39,505	437	35,806	385
Petroleum (crude) thousand 42-gallon barrels	4,922	21,263	4,337	19,300	4,387	19,701	4,160	18,698
Sand and gravel thousand short tons	18,502	29,606	17,567	29,562	17,479	29,614	18,101	31,076
Stone do	56,806	99,627	59,088	99,233	60,155	103,157	62,812	108,151
Zinc (recoverable content of ores, etc.)[10] short tons	27,635	8,014	28,080	8,143	35,067	9,468	30,382	8,203
Value of items that cannot be disclosed: Clays (kaolin), cobalt, gold, iron ore, scrap mica, pyrites, pyrophyllite, silver, and tripoli	XX	34,587	XX	30,281	XX	27,718	XX	28,780
Total	XX	913,823	XX	903,408	XX	898,398	XX	904,044
RHODE ISLAND								
Sand and gravel thousand short tons	1,681	$1,811	2,276	$2,212	2,334	$2,416	2,291	$2,546
Stone do	437	1,119	535	1,734	481	1,618	W	W
Value of items that cannot be disclosed: Other nonmetals and values indicated by symbol W	XX	1	XX	1	XX	1	XX	1,676
Total	XX	2,931	XX	3,947	XX	4,035	XX	4,222
SOUTH CAROLINA								
Clays thousand short tons	1,837	$8,539	2,139	$8,830	1,733	$8,048	1,936	$8,923
Sand and gravel do	5,248	6,688	6,016	7,668	5,248	7,178	5,662	8,074
Stone do	[4]5,948	[4]8,447	8,129	12,510	[4]8,310	[4]12,366	8,942	13,717
Value of items that cannot be disclosed: Barite (1965–66), cement, feldspar, kyanite, scrap mica, peat, pyrites, stone (crushed limestone 1965 and dimension granite 1965, 1967), and vermiculite	XX	17,587	XX	16,585	XX	20,682	XX	21,144
Total	XX	41,261	XX	45,593	XX	48,274	XX	51,858
SOUTH DAKOTA								
Beryllium concentrate short tons, gross weight	W	W	124	$40	W	W	75	$35
Cement:								
Portland thousand 376-pound barrels	1,575	$5,127	1,974	6,367	1,406	$4,815	1,826	6,228
Masonry thousand 280-pound barrels	55	180	51	170	54	178	54	180
Clays thousand short tons	223	1,220	231	870	199	799	226	1,119
Coal (lignite) do	10	49	10	45	5	27	---------	---------
Feldspar long tons	51,560	346	53,810	369	61,411	420	39,077	264
Gem stones	NA	20	NA	20	NA	30	NA	34
Gold (recoverable content of ores, etc.) troy ounces	628,259	21,989	606,467	21,226	601,785	21,062	593,052	[5]23,283
Gypsum thousand short tons	7	27	17	68	12	49	16	65
Lithium minerals short tons	150	[6]5	W	W	W	W	W	W
Petroleum (crude) thousand 42-gallon barrels	219	438	239	479	211	502	187	401
Sand and gravel thousand short tons	13,998	14,155	13,630	13,585	13,463	13,737	11,558	11,578

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
SOUTH DAKOTA—Continued								
Silver (recoverable content of ores, etc.) thousand troy ounces	129	$167	110	$142	121	$188	138	$295
Stone thousand short tons	1,554	5,387	2,186	7,995	1,866	9,694	1,860	9,687
Value of items that cannot be disclosed: Columbium-tantalum concentrates (1967), lime, scrap mica, molybdenum (1965–67), tin (1966), uranium, vanadium (1965–67), and values indicated by symbol W	XX	1,553	XX	1,796	XX	1,117	XX	917
Total	XX	50,663	XX	53,172	XX	52,618	XX	54,086
TENNESSEE								
Barite thousand short tons	31	$442	29	$412	15	$235	21	$362
Cement:								
Portland thousand 376-pound barrels	8,724	27,535	8,177	25,718	8,062	25,548	8,488	27,691
Masonry thousand 280-pound barrels	1,185	3,140	1,095	2,822	1,092	2,992	1,370	3,836
Clays thousand short tons	1,495	6,103	[3] 1,359	[3] 4,909	1,574	5,152	[3] 1,562	[3] 5,772
Coal (bituminous) do	5,865	20,930	6,309	23,763	6,832	26,974	8,148	29,647
Copper (recoverable content of ores, etc.) short tons	14,823	10,495	15,410	11,148	14,600	11,162	14,196	11,881
Gold (recoverable content of ores, etc.) troy ounces	122	4	141	5	181	6	140	[5] 5
Lead (recoverable content of ores, etc.) short tons	---------	---------	181	55	---------	---------	---------	---------
Natural gas million cubic feet	85	16	---------	---------	58	11	48	9
Petroleum (crude) thousand 42-gallon barrels	11	W	7	W	7	W	6	W
Phosphate rock thousand short tons	2,954	22,296	3,125	23,886	2,992	22,571	3,149	23,628
Sand and gravel do	8,193	10,690	8,628	11,142	7,975	10,679	7,344	11,140
Silver (recoverable content of ores, etc.) thousand troy ounces	94	122	101	130	130	202	90	192
Stone [4] thousand short tons	28,888	38,859	31,260	41,432	31,463	41,958	32,083	43,854
Zinc (recoverable content of ores, etc.) short tons	122,387	35,737	103,117	29,904	113,065	31,303	124,039	33,491
Value of items that cannot be disclosed: Clay (fuller's earth 1966–68), lime, pyrites, stone (crushed sandstone, dimension sandstone 1967), and values indicated by symbol W	XX	6,572	XX	7,258	XX	10,779	XX	9,826
Total	XX	182,941	XX	182,584	XX	189,572	XX	201,334
TEXAS								
Cement:								
Portland thousand 376-pound barrels	30,820	$97,598	30,827	$97,188	31,944	$99,329	34,499	$107,532
Masonry thousand 280-pound barrels	968	3,011	884	2,872	888	2,847	1,059	3,371
Clays thousand short tons	[3] 4,469	[3] 6,865	4,516	7,187	4,497	8,081	4,687	8,860

Gem stones	NA	150	NA	150	NA	150	NA	150
Gypsum ... thousand short tons	1,045	3,794	899	3,258	984	3,419	1,039	3,616
Helium: Crude ... thousand cubic feet	1,015,708	10,380	1,030,500	10,605	977,600	10,246	1,038,700	11,100
Grade A ... do	350,000	12,250	364,100	12,744	335,900	9,900	362,100	9,400
Lime ... thousand short tons	1,338	19,663	1,473	18,696	1,564	20,713	1,564	21,154
Natural gas ... million cubic feet	6,636,555	858,396	6,953,790	903,993	7,188,900	948,935	7,495,414	1,011,881
Natural gas liquids:								
Natural gasoline and cycle products ... thousand 42-gallon barrels	89,821	256,959	92,625	269,332	95,991	277,105	97,075	269,182
LP gases ... do	139,229	204,666	151,425	260,755	177,367	320,326	189,162	278,068
Perlite ... short tons	1,000	8	W	W	W	W	---	---
Petroleum (crude) ... thousand 42-gallon barrels	1,000,749	2,962,119	1,057,706	3,141,387	1,119,962	3,375,565	1,133,380	3,450,707
Salt ... thousand short tons	6,964	30,771	7,724	33,797	8,344	36,435	8,534	42,663
Sand and gravel ... do	32,649	36,075	26,222	31,313	31,398	39,170	31,843	41,546
Stone ... do	39,520	53,659	43,578	56,659	49,424	61,577	48,480	58,006
Sulfur (Frasch process) ... thousand long tons	3,674	83,282	3,703	96,820	3,448	111,931	2,571	105,482
Talc and soapstone ... short tons	64,211	204	102,399	367	90,836	356	125,880	517
Value of items that cannot be disclosed: Native asphalt, barite (1965–66), bromine, clays (fuller's earth 1965), coal (lignite), graphite, iron ore, magnesium chloride (for metal), magnesium compounds (except for metal), mercury, pumice, sodium sulfate, uranium, vermiculite (1967–68), and values indicated by symbol W	XX	79,026	XX	74,918	XX	80,286	XX	82,596
Total	XX	4,718,826	XX	5,022,041	XX	5,406,371	XX	5,505,831
UTAH								
Carbon dioxide, natural ... thousand cubic feet	86,201	$6	94,006	$7	65,664	$5	57,747	$4
Clays [3] ... thousand short tons	149	332	89	240	114	288	160	476
Coal (bituminous) ... do	4,992	31,811	4,635	26,763	4,175	24,281	4,316	24,893
Copper (recoverable content of ores, etc.) ... short tons	259,138	183,470	265,383	191,978	168,609	128,905	228,245	191,027
Fluorspar ... do	W	W	W	W	W	W	8,762	213
Gem stones	NA	75	NA	75	NA	80	NA	83
Gold (recoverable content of ores, etc.) ... troy ounces	426,299	14,921	438,786	15,356	288,350	10,092	334,419	[5] 13,129
Iron ore (usable) ... thousand long tons, gross weight	2,139	14,229	1,956	13,478	1,708	11,916	1,764	11,281
Lead (recoverable content of ores, etc.) ... short tons	37,700	11,762	64,124	19,385	53,813	15,068	45,205	11,945
Lime ... thousand short tons	189	3,470	200	3,640	169	3,182	174	3,439
Natural gas ... million cubic feet	71,616	8,952	69,366	8,809	48,965	6,463	46,151	7,292
Petroleum (crude) ... thousand 42-gallon barrels	25,298	66,045	24,112	63,760	24,048	63,221	23,504	62,826
Pumice ... thousand short tons	W	W	W	W	W	W	8	19
Salt ... do	384	3,591	427	3,770	408	3,525	405	3,756
Sand and gravel ... do	10,032	10,464	12,368	12,937	9,412	8,631	10,293	9,364
Silver (recoverable content of ores, etc.) ... thousand troy ounces	5,636	7,287	7,755	10,028	4,875	7,556	5,121	10,982
Stone ... thousand short tons	2,328	4,765	2,246	4,269	1,831	4,108	1,953	4,812
Sulfur ore ... long tons, gross weight	2,156	3	---	---	---	---	---	---
Uranium (recoverable content U_3O_8) ... thousand pounds	W	W	1,225	9,797	1,287	10,300	1,712	13,175
Vanadium (recoverable in ore and concentrate) ... short tons	387	1,353	353	1,519	471	2,024	563	2,010
Zinc (recoverable content of ores, etc.) ... do	27,747	8,102	37,323	10,824	34,251	9,483	33,153	8,951
Value of items that cannot be disclosed: Asphalt (gilsonite), cement, clays (fire clay 1965–67, kaolin), gypsum, magnesium compounds (1966–68), molybdenum, natural gas liquids, perlite (1965–67), phosphate rock, potassium salts, pyrites (1966–68), tungsten concentrate (1967–68), and values indicated by symbol W	XX	68,510	XX	52,243	XX	45,349	XX	44,774
Total	XX	439,148	XX	448,878	XX	354,477	XX	423,951

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
VERMONT								
Peat ---- short tons	780	$3	333	$5	280	$4	W	W
Sand and gravel ---- thousand short tons	2,084	1,670	2,323	1,744	3,718	2,178	3,587	$2,806
Stone ---- do	2,591	21,564	2,650	19,926	2,761	20,520	2,536	21,401
Value of items that cannot be disclosed: Asbestos, clays, gem stones, lime, talc, and values indicated by symbol W	XX	4,155	XX	4,235	XX	4,566	XX	4,508
Total	XX	27,392	XX	25,910	XX	27,268	XX	28,715
VIRGINIA								
Clays ---- thousand short tons	1,415	$1,657	1,486	$1,813	1,382	$1,623	1,462	$1,714
Coal (bituminous) ---- do	34,053	139,291	35,565	153,341	36,721	171,183	36,966	178,946
Gem stones	NA	7	NA	7	NA	7	NA	7
Lead (recoverable content of ores, etc.) ---- short tons	3,651	1,139	3,078	930	3,430	960	3,573	944
Lime ---- thousand short tons	847	10,584	840	10,486	829	10,345	919	11,138
Natural gas ---- million cubic feet	3,152	942	4,249	1,275	3,818	1,149	3,389	1,013
Petroleum (crude) ---- thousand 42-gallon barrels	4	W	1	W	3	W	3	W
Sand and gravel ---- thousand short tons	15,322	18,019	17,191	16,635	9,863	12,494	10,859	13,644
Soapstone ---- short tons	3,549	9	3,989	10	W	W	3,928	10
Stone ---- thousand short tons	36,350	59,397	34,151	55,550	31,324	52,470	31,217	53,533
Zinc (recoverable content of ores, etc.)[10] ---- short tons	20,491	5,942	17,666	5,123	18,846	5,088	19,257	5,199
Value of items that cannot be disclosed: Aplite, cement, feldspar, gypsum, iron ore (pigment materials), kyanite, salt, titanium concentrate, and values indicated by symbol W	XX	30,990	XX	29,127	XX	28,366	XX	29,515
Total	XX	267,977	XX	274,297	XX	283,685	XX	295,663
WASHINGTON								
Barite ---- thousand short tons	(6)	$1	----	----	(6)	$1	----	----
Carbon dioxide ---- thousand cubic feet	11,848	3	W	W	W	W	----	----
Cement:								
Portland ---- thousand 376-pound barrels	6,258	22,351	6,820	$24,340	5,614	20,581	6,328	$23,030
Masonry ---- thousand 280-pound barrels	62	201	60	187	65	200	56	175
Clays[3] ---- thousand short tons	162	211	185	249	189	203	140	213
Coal (bituminous) ---- do	55	497	59	514	59	517	178	823
Copper (recoverable content of ores, etc.) ---- short tons	30	21	34	25	21	16	22	18
Gem stones	NA	75	NA	75	NA	75	NA	100
Lead (recoverable content of ores, etc.) ---- short tons	6,328	1,974	5,859	1,771	2,762	773	5,655	1,494

Peat……do……	29,729	131	25,599	136	40,608	181	40,440	159
Sand and gravel……thousand short tons……	31,301	27,234	29,002	26,806	28,164	27,520	31,482	27,839
Stone……do……	12,461	17,446	13,250	20,273	14,454	19,099	14,331	16,690
Talc and soapstone……short tons……	2,861	17	3,880	22	4,916	26	W	W
Zinc (recoverable content of ores, etc.)……do……	22,230	6,491	24,772	7,184	21,540	5,964	13,884	3,749
Value of items that cannot be disclosed: Clays (fire clay, bentonite 1965), diatomite, gold, gypsum (1966–68), lime, magnesite, mercury (1965, 1968), olivine, pumice, silver, tungsten (1965, 1967), uranium (1965–66), vanadium (1966), and values indicated by symbol W……	XX	11,011	XX	7,514	XX	6,911	XX	7,095
Total……	XX	87,664	XX	89,096	XX	82,067	XX	81,385
WEST VIRGINIA								
Clays [3]……thousand short tons……	289	$328	300	$334	245	$254	193	$219
Coal (bituminous)……do……	149,191	726,096	149,681	753,851	153,749	800,683	145,921	775,720
Lime……do……	W	W	240	3,492	217	3,099	207	2,848
Natural gas……million cubic feet……	207,416	48,743	211,610	49,940	211,460	50,962	236,971	62,086
Petroleum (crude)……thousand 42-gallon barrels……	3,530	13,591	3,674	14,623	3,561	14,244	3,312	13,149
Salt……thousand short tons……	1,153	5,539	1,147	5,446	1,127	5,137	1,308	4,971
Sand and gravel……do……	5,253	11,480	5,448	11,569	5,827	12,167	5,657	11,900
Stone [4]……do……	8,482	14,587	9,738	16,354	9,445	16,447	9,011	16,789
Value of items that cannot be disclosed: Calcium-magnesium chloride (1965–67), cement, clay (fire clay), gem stones, natural gas liquids, stone (dimension sandstone) and values indicated by symbol W……	XX	39,240	XX	36,191	XX	34,865	XX	30,026
Total……	XX	859,604	XX	891,800	XX	937,858	XX	917,708
WISCONSIN								
Clays……thousand short tons……	119	$147	123	$148	89	$112	17	$34
Iron ore (usable)……thousand long tons, gross weight……	141	W	---------	---------	---------	---------	---------	---------
Lead (recoverable content of ores, etc.)……short tons……	1,645	513	1,694	512	1,596	447	1,126	298
Lime……thousand short tons……	197	3,076	204	3,186	212	3,414	224	3,620
Peat……short tons……	3,090	122	2,379	164	1,823	W	1,902	153
Sand and gravel……thousand short tons……	38,751	27,707	41,523	30,718	42,542	32,955	39,807	30,903
Stone……do……	15,344	21,924	16,150	23,735	17,122	24,863	17,000	25,223
Zinc (recoverable content of ores, etc.)……short tons……	26,993	7,882	24,775	7,185	28,953	8,016	25,711	6,942
Value of items that cannot be disclosed: Abrasive stones, cement, gem stones, and values indicated by symbol W……	XX	11,628	XX	10,367	XX	9,805	XX	4,522
Total……	XX	72,999	XX	76,010	XX	79,612	XX	71,695
WYOMING								
Clays……thousand short tons……	1,352	$18,633	1,559	$15,874	1,495	$14,313	1,828	$17,275
Coal (bituminous)……do……	3,260	10,150	3,670	11,840	3,588	11,876	3,829	12,117
Copper (recoverable content of ores, etc.)……short tons……	6	4	---------	---------	---------	---------	---------	---------

See footnotes at end of table.

Table 5.—Mineral production[1] in the United States, by States—Continued

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
	WYOMING—Continued							
Gem stones	NA	$120	NA	$120	NA	$125	NA	$127
Gold (recoverable content of ores, etc.) troy ounces	3	(6)	---------	---------	---------	---------	---------	---------
Iron ore (usable) thousand long tons, gross weight	2,087	25,198	1,978	19,700	1,854	19,186	1,967	19,452
Lime thousand short tons	W	W	W	W	W	W	28	W
Natural gas million cubic feet	235,849	31,840	243,381	35,290	240,074	35,051	248,481	36,278
Natural gas liquids:								
Natural gasoline thousand 42-gallon barrels	2,264	6,195	2,295	6,281	2,361	6,447	2,331	6,501
LP gases do	3,418	6,020	3,954	7,308	4,139	7,648	3,917	7,090
Petroleum (crude) do	138,314	345,785	134,470	344,243	136,312	351,685	144,250	380,589
Sand and gravel thousand short tons	7,996	8,373	7,187	7,496	8,181	8,253	9,350	8,973
Stone do	1,594	2,791	1,393	2,560	1,246	2,375	1,434	2,754
Uranium (recoverable content U_3O_8) thousand pounds	W	W	4,593	36,741	4,655	37,243	5,928	44,343
Vanadium (recoverable in ore and concentrate) short tons	W	444	W	555	W	W	---------	---------
Value of items that cannot be disclosed: Beryllium concentrate (1965), cement, feldspar, gypsum, phosphate rock, pumice (1967), silver (1965), sodium carbonates and sulfates, vermiculite (1967), and values indicated by symbol W	XX	64,901	XX	36,379	XX	36,494	XX	40,691
Total	XX	515,454	XX	524,387	XX	530,696	XX	576,190

---

[e] Estimate. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data. XX Not applicbale.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Excludes certain cement, included with "Value of items that cannot be disclosed."

[3] Excludes certain clays, included with "Value of items that cannot be disclosed."

[4] Excludes certain stone, included with "Value of items that cannot be disclosed."

[5] Based on average U. S. Treasury price ($35.00) Jan. 1, 1968 through Mar. 15, 1968, and the New York selling price for the remainder of the year.

[6] Less tha ½ unit.

[7] Excludes shipments from Nye Metals, Inc., included with "Value of items that cannot be disclosed."

[8] Final figure, supersedes figure given in commodity section volume I–II.

[9] Excludes salt in brine, included with "Value of items that cannot be disclosed."

[10] Recoverable zinc valued at the yearly average price of Prime Western slab zinc, East St. Louis market. Represents value established after transportation, smelting and manufacturing charges have been added to the value of ore at mine.

Table 6.—Mineral production[1] in the Canal Zone and islands administered by the United States[2]

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
American Samoa:								
Pumice thousand short tons	------	------	17	$22	28	$24	21	$51
Sand and gravel do	60	$55	20	18	7	7	20	19
Stone do	60	60	12	12	28	50	53	79
Total	XX	115	XX	52	XX	81	XX	149
Canal Zone:								
Sand and gravel thousand short tons	83	85	72	91	56	94	55	77
Stone (crushed) do	153	366	114	267	100	245	106	290
Total	XX	451	XX	358	XX	339	XX	367
Guam: Stone thousand short tons	483	925	900	1,396	511	820	560	998
Virgin Islands: Stone (crushed) do	68	302	88	303	183	851	366	1,555
Wake: Stone (crushed) do	1	4	11	66	31	150	41	132

XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

[2] Production data for Wake furnished by U.S. Department of Transportation, Federal Aviation Administration; Guam, by the Government of Guam: American Samoa, by the Government of American Samoa.

Table 7.—Mineral production[1] in the Commonwealth of Puerto Rico

Mineral	1965		1966		1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Cement thousand 376-pound barrels	7,284	$23,415	7,603	$24,277	8,447	$27,397	8,923	$27,577
Clays thousand short tons	357	288	350	271	291	244	512	481
Lime do	27	867	30	960	35	1,106	39	1,187
Salt do	8	138	11	183	12	195	32	395
Sand and gravel do	8,147	12,405	9,879	14,554	14,101	21,633	16,146	24,723
Stone do	5,344	9,111	5,732	10,541	7,269	12,795	7,367	13,580
Total	XX	46,224	XX	50,786	XX	63,370	XX	67,943

XX Not applicable.

[1] Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 8.—U.S. exports of principal minerals and products

Mineral	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Ingots, slabs, crude ... short tons	209,009	$99,961	180,279	$85,858
Scrap ... do	54,531	17,686	49,427	16,017
Plates, sheets, bars, etc ... do	96,275	70,757	114,062	77,418
Castings and forgings ... do	2,816	11,173	3,527	10,104
Antimony: Metals and alloys, crude ... short tons	82	75	109	54
Bauxite, including bauxite concentrates ... thousand long tons	2	218	7	360
Aluminum sulfate ... short tons	16,173	531	18,252	571
Other aluminum compounds ... do	578,627	51,075	915,581	74,527
Beryllium ... pounds	76,117	530	93,475	622
Bismuth: Metals and alloys ... do	152,684	395,695	120,466	292,245
Cadmium ... thousand pounds	691	1,669	530	1,400
Chrome:				
Ore and concentrates:				
Exports ... thousand short tons	8	328	13	517
Reexports ... do	157	5,422	126	5,351
Chromic acid ... do	1	392	1	675
Ferrochrome ... do	13	3,479	27	5,735
Cobalt ... thousand pounds	1,498	2,367	2,539	4,348
Columbium metals, alloys and other forms ... thousand pounds	6	341	8	291
Copper:				
Ore, concentrate, composition metal and unrefined (copper content) ... short tons	59,692	32,951	80,739	58,481
Refined copper and semimanufactures ... do	[r] 200,084	[r] 213,644	297,992	308,098
Other copper manufactures ... do	6,570	7,472	4,669	5,681
Copper sulfate or blue vitriol ... short tons	979	776	927	718
Copper base alloys ... do	78,213	75,809	98,534	98,322
Ferroalloys:				
Ferrosilicon ... do	11,774	3,228	18,372	4,481
Ferrophosphorous ... do	22,901	847	36,708	930
Gold:				
Ore and base bullion ... troy ounces	112,578	3,940	181,385	6,765
Bullion, refined ... do	28,607,404	1,001,259	23,781,006	832,394
Iron ore ... thousand long tons	[r] 5,906	71,585	5,884	70,835
Iron and steel:				
Pig iron ... short tons	7,451	319	10,941	657
Iron and steel products (major):				
Semimanufactures ... do	[r] 1,375,920	[r] 288,709	1,759,527	307,885
Manufactured steel mill products ... do	[r] 521,777	[r] 266,607	700,215	293,775
Iron and steel scrap: Ferrous scrap, including rerolling materials ... short tons	[r] 7,668,814	251,236	6,692,058	202,849
Lead:				
Pigs, bars, anodes ... do	6,536	4,767	8,281	4,740
Scrap ... do	394	198	937	219
Magnesium:				
Metal and alloys and semimanufactured forms, n.e.c ... short tons	13,173	9,115	19,457	13,049
Manganese:				
Ore and concentrate ... do	15,375	1,502	18,500	2,042
Ferromanganese ... do	1,861	760	3,710	645
Mercury:				
Exports ... 76-pound flasks	2,627	1,281	7,496	3,951
Reexports ... do	475	193	103	54
Molybdenum:				
Ore and concentrates (molybdenum content) ... thousand pounds	30,000	51,434	29,006	48,070
Metals and alloys, crude and scrap ... do	50	131	293	217
Wire ... do	34	661	26	551
Semifabricated forms, n.e.c ... do	292	702	118	487
Powder ... do	241	434	53	170
Ferromolybdenum ... do	1,533	2,436	863	1,194
Nickel:				
Alloys and scrap (including Monel metal), ingots, bars, sheets, etc ... short tons	26,169	53,225	28,555	56,386
Catalysts ... do	3,441	9,387	3,340	7,299
Nickel-chrome electric resistance wire ... do	565	2,530	624	2,652
Semifabricated forms, n.e.c ... do	1,362	5,587	1,162	5,336
Platinum:				
Ore, concentrate, metal and alloys in ingots, bars, sheets, anodes, and other forms, including scrap ... troy ounces	161,585	19,248	222,998	30,997

See footnotes at end of table.

Table 8.—U.S. exports of principal minerals and products—Continued

Mineral	1967 Quantity	1967 Value (thousands)	1968 Quantity	1968 Value (thousands)
Metals—Continued				
Platinum—Continued				
Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (metal and alloys including scrap) troy ounces	[r] 118,267	[r] 9,772	172,159	18,522
Platinum group manufactures, except jewelry	NA	2,378	NA	2,493
Rare earths:				
Cerium ore, metal, alloys and lighter flints pounds	141,338	303	89,858	303
Silver:				
Ore and base bullion thousand troy ounces	2,365	4,242	23,129	47,549
Bullion, refined do	68,404	91,718	102,632	199,551
Tantalum:				
Ore, metal, and other forms thousand pounds	134	1,724	171	1,899
Powder do	[r] 51	[r] 1,599	84	2,668
Tin:				
Ingots, pigs, bars, etc:				
Exports long tons	2,050	6,962	3,813	12,734
Reexports do	429	1,412	682	2,267
Tin scrap and other tin-bearing material except tinplate scrap long tons	2,957	1,490	5,128	2,676
Titanium:				
Ore and concentrate short tons	3,027	167	4,238	276
Sponge (including iodide titanium and scrap) short tons	1,429	1,703	2,756	1,748
Intermediate mill shapes and mill products, n.e.c short tons	[r] 1,812	[r] 13,366	1,228	7,575
Dioxide and pigments do	25,852	7,165	30,188	8,227
Tungsten: Ore and concentrates:				
Exports do	944	[r] 2,934	604	1,705
Reexports do	269	576	56	117
Vanadium ore and concentrate, pentoxide, etc. (vanadium content) thousand pounds	1,575	4,043	925	1,972
Zinc:				
Slabs, pigs, or blocks short tons	16,809	4,287	33,011	9,797
Sheets, plates, strips, or other forms, n.e.c. short tons	3,565	2,709	3,048	2,228
Scrap (zinc content) do	1,665	530	2,293	886
Semifabricated forms, n.e.c do	2,161	1,177	15,000	3,840
Zirconium:				
Ore and concentrate do	2,729	360	2,026	361
Metals and alloys and other forms pounds	637,612	6,909	693,927	8,709
Nonmetals:				
Abrasives:				
Dust and powder of precious or semiprecious stones, including diamond dust and powder thousand carats	4,317	12,526	6,015	16,616
Crushing bort do	18	210	26	168
Industrial diamonds do	148	924	300	1,153
Diamond grinding wheels do	429	2,946	594	3,010
Other natural and artificial, metallic abrasives and products	NA	34,290	NA	39,319
Asbestos: Unmanufactured:				
Exports short tons	47,356	5,951	41,217	4,677
Reexports do	362	74	19	2
Boron: Boric acid, borates, crude and refined short tons	186,482	18,710	206,823	20,347
Cement thousand 376-pound barrels	980	4,452	942	3,884
Clays:				
Kaolin or china clay short tons	321,929	9,921	889,882	12,995
Fire clay do	176,367	2,789	151,940	2,672
Other clays do	651,366	19,853	977,804	28,575
Fluorspar do	10,345	517	12,614	496
Graphite do	3,569	460	4,169	509
Gypsum:				
Crude, crushed or calcined thousand short tons	39	1,707	39	1,688
Manufactures, n.e.c	NA	1,211	NA	1,868
Kyanite and related minerals short tons	21,428	1,408	20,477	1,311
Lime do	52,143	1,099	68,915	1,437
Mica sheet, waste and scrap and ground pounds	14,301,524	781	27,014,321	1,408
Manufactured do	526,690	1,753	474,509	1,358

See footnotes at end of table.

Table 8.—U.S. exports of principal minerals and products—Continued

Mineral	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued				
Mineral-earth pigments: iron oxide, natural and manufactured short tons	3,123	$1,312	3,321	$1,257
Nitrogen compounds (major) thousand short tons	2,911	165,008	4,042	186,472
Phosphate rock do	10,282	94,413	12,083	104,559
Phosphatic fertilizers (superphosphates) do	743	35,139	1,289	56,359
Pigments and compounds (lead and zinc):				
Lead pigments short tons	1,909	772	1,877	770
Zinc pigments do	4,175	1,331	4,940	1,483
Potash:				
Fertilizer do	1,146,131	35,010	1,339,491	39,610
Chemical do	29,060	4,886	33,397	5,114
Quartz, natural, quartzite, cryolite and chiolite short tons	1,228	285	751	168
Salt:				
Crude and refined thousand short tons	678	4,583	728	4,650
Shipments to noncontiguous Territories thousand short tons	11	892	18	1,772
Sodium and sodium compounds:				
Sodium sulfate thousand short tons	28	856	56	1,844
Sodium carbonate do	304	9,914	288	9,131
Stone:				
Dolomite, block do	113	1,756	102	1,518
Limestone, crushed, ground, broken do	1,159	3,496	1,297	3,294
Marble and other building and monumental thousand cubic feet	NA	958	NA	849
Stone, crushed, ground, broken thousand short tons	306	3,743	292	3,278
Manufactures of stone	NA	1,203	NA	1,030
Sulfur:				
Crude thousand long tons	2,043	81,492	1,549	65,650
Crushed, ground, flowers of do	150	9,522	53	3,855
Talc, crude and ground short tons	66,195	3,450	65,648	3,521
Fuels:				
Carbon black thousand pounds	[r] 236,035	[r] 24,410	263,122	28,626
Coal:				
Anthracite thousand short tons	595	7,622	518	6,553
Bituminous do	[r] 49,528	[r] 475,015	50,637	495,980
Briquets do	120	2,293	65	2,698
Coke do	710	16,492	792	18,613
Petroleum:				
Crude thousand barrels	[r] 26,541	[r] 86,387	1,803	4,452
Gasoline do	[r] 3,602	19,106	2,061	12,390
Jet do	[r] 283	1,142	258	1,025
Naphtha do	[r] 2,299	21,999	2,550	26,421
Kerosine do	158	1,252	431	3,644
Distillate oil do	[r] 6,041	[r] 16,304	1,866	8,311
Residual oil do	[r] 22,150	43,793	20,013	40,746
Lubricating oil do	[r] 17,771	[r] 208,620	17,666	203,807
Asphalt do	[r] 348	3,167	354	3,059
Liquefied petroleum gases do	[r] 9,256	32,182	10,599	32,487
Wax do	[r] 1,676	34,077	1,588	31,934
Coke do	[r] 16,279	55,187	19,508	68,068
Petrochemical feedstocks do	[r] 2,983	15,344	2,781	15,338
Miscellaneous do	[r] 893	[r] 19,455	1,040	21,575
Total	XX	4,876,648	XX	4,949,527

[r] Revised. XX Not applicable.
NA Not available.

Table 9.—U.S. imports for consumption of principal minerals and products

Mineral	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals:				
Aluminum:				
Metal ... short tons	449,716	$194,995	685,699	$298,759
Scrap ... do	30,489	10,040	37,521	12,134
Plates, sheets, bars, etc ... do	58,341	40,243	62,135	41,816
Antimony:				
Ore (antimony content) ... do	10,517	4,090	10,614	4,145
Needle or liquated ... do	29	18	60	42
Metal ... do	2,654	1,849	2,693	2,087
Oxide ... do	5,098	3,762	4,801	3,540
Arsenic: White (As_2O_3 content) ... do	27,075	2,503	25,195	2,626
Bauxite: Crude ... thousand long tons	[r] 11,594	151,418	10,976	140,228
Beryllium ore ... short tons	9,511	3,167	3,822	1,413
Bismuth (general imports) ... pounds	1,379,729	5,172	1,265,671	4,718
Boron carbide ... do	214,620	469	227,486	575
Cadmium:				
Metal ... thousand pounds	1,587	3,817	1,927	4,602
Flue dust (cadmium content) ... do	1,166	1,093	1,605	1,796
Calcium:				
Metal ... pounds	423,631	370	137,251	120
Chloride ... short tons	4,385	158	14,069	523
Chromite:				
Ore and concentrates (Cr_2O_3 content) thousand short tons	568	21,854	499	18,189
Ferrochrome (chromium content) ... do	39	13,758	41	14,197
Metal ... do	1	1,842	1	2,053
Cobalt:				
Metal ... thousand pounds	7,946	14,420	9,219	16,285
Oxide (gross weight) ... do	1,044	1,670	1,186	2,118
Salts and compounds (gross weight) ... do	167	200	107	90
Columbium ore ... do	7,431	5,266	3,657	2,848
Copper: (copper content)				
Ore and concentrates ... short tons	35,673	28,820	71,884	66,291
Regulus, black, coarse ... do	2	35	8	4
Unrefined, black, blister ... do	[r] 270,728	[r] 217,473	274,180	224,018
Refined in ingots, etc ... do	[r] 332,290	[r] 311,415	403,630	438,608
Old and scrap ... do	[r] 16,717	[r] 14,802	11,571	12,117
Old and clippings ... do	2,549	2,479	2,131	2,042
Ferroalloys: Ferrosilicon (silicon content) short tons	15,337	4,456	10,612	3,207
Gold:				
Ore and base bullion ... troy ounces	219,382	7,671	213,662	7,855
Bullion ... do	710,487	24,876	5,730,853	218,408
Iron ore ... thousand long tons	[r] 44,611	[r] 443,918	43,941	453,758
Iron and steel:				
Pig iron ... short tons	605,234	27,599	785,899	30,486
Iron and steel products (major):				
Iron products ... short tons	[r] 27,614	[r] 6,450	39,542	9,606
Steel products ... do	[r] 11,457,973	[r] 1,319,830	17,853,995	1,989,482
Scrap ... do	215,635	8,181	276,498	10,784
Tinplate ... do	13,527	381	17,727	541
Lead:				
Ore, flue dust, matte (lead content) short tons	144,156	29,111	96,863	18,990
Base bullion (lead content) ... do	677	1,224	63	643
Pigs and bars (lead content) ... do	363,596	88,697	337,620	81,264
Reclaimed, scrap, etc. (lead content) short tons	9,368	1,951	4,249	748
Sheets, pipe, and shot ... do	1,212	322	893	256
Babbitt metal and solder (lead content) short tons	413	1,423	566	2,244
Manufactures ... do	1,363	524	893	256
Magnesium:				
Metallic and scrap ... do	[r] 9,235	[r] 4,920	4,086	2,219
Alloys (magnesium content) ... do	354	1,529	705	1,129
Sheets, tubing, ribbons, wire and other forms (magnesium content) ... short tons	[r] 132	[r] 422	25	416
Manganese:				
Ore (35 percent or more manganese) (manganese content) ... short tons	[r] 975,760	[r] 55,710	870,390	45,264
Ferromanganese (manganese content) ... do	[r] 167,612	[r] 26,437	160,694	21,430

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products—Continue

Mineral	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Metals—Continued				
Mercury:				
Compounds pounds	14,011	$14	33,473	$4
Metal 76-pound flasks	24,348	r 10,553	23,246	11,16
Minor metals: Selenium and salts pounds	300,638	1,545	582,535	3,07
Nickel:				
Pigs, ingots, shot, cathodes short tons	113,860	193,848	108,158	201,31
Scrap do	1,104	1,240	1,969	2,56
Oxide do	6,208	8,130	6,388	8,91
Platinum group:				
Unrefined materials:				
Grains and nuggets, including crude dust and residues troy ounces	41,798	5,195	64,777	10,18
Sweeping, waste and scrap do	102,067	6,880	54,831	3,86
Osmiridium do	4,179	458	11,736	2,10
Refined metal:				
Platinum do	322,764	38,282	383,366	45,58
Palladium do	737,082	r 27,503	1,165,511	50,83
Iridium do	8,874	1,505	5,503	1,01
Osmium do	r 481	r 170	272	54
Rhodium do	47,689	10,079	71,016	10,36
Ruthenium do	56,563	2,049	11,162	454
Radium:				
Radioactive substitutes	NA	3,000	NA	3,24
Rare earths: Ferrocerium and other cerium alloys pounds	r 7,241	r 35	23,003	77
Silver:				
Ore and base bullion thousand troy ounces	25,642	33,437	28,786	49,587
Bullion do	29,878	43,650	41,923	88,21
Tantalum: Ore thousand pounds	r 1,730	r 5,518	1,230	4,164
Tin:				
Ore (tin content) long tons	3,255	7,635	2,282	5,287
Blocks, pigs, grains, etc do	50,223	166,529	57,358	181,940
Dross, skimmings, scrap, residues and tin alloys, n.s.p.f long tons	449	462	487	582
Tin foil, powder, flitters, etc	NA	r 355	NA	2,742
Titanium:				
Ilmenite short tons	207,906	5,145	246,109	5,167
Rutile do	167,100	r 11,943	174,366	12,653
Metal pounds	14,950,359	14,415	7,610,236	8,148
Ferrotitanium do	306,317	85	398,923	143
Compounds and mixtures do	96,251,565	16,726	111,080,989	19,618
Tungsten: (tungsten content)				
Ore and concentrate thousand pounds	1,699	3,784	1,743	3,272
Metal do	129	524	33	356
Other alloys pounds	r 10,773	65	22,951	120
Zinc:				
Ore (zinc content) short tons	431,319	58,075	451,787	68,466
Blocks, pigs, and slabs do	222,002	57,531	306,651	76,035
Sheets do	648	276	754	290
Old, dross, and skimmings do	3,963	673	1,459	182
Dust do	3,771	1,211	8,100	2,443
Manufactures	NA	318	NA	447
Zirconium: Ore, including zirconium sand short tons	59,303	1,891	59,900	2,014
Nonmetals:				
Abrasives: Diamonds (industrial) thousand carats	r 17,112	r 63,576	13,676	60,277
Asbestos short tons	645,112	65,743	737,909	72,930
Barite:				
Crude and ground do	532,314	4,659	662,705	5,666
Witherite do	1,260	53	2,029	59
Chemicals do	5,243	682	5,977	843
Cement thousand 376-pound barrels	5,913	14,698	7,370	17,511
Clays:				
Raw short tons	103,404	2,039	91,205	1,709
Manufactured do	5,382	252	6,177	242
Cryolite do	36,319	4,118	33,772	5,455
Feldspar: Crude long tons	280	8	----------	----------
Fluorspar short tons	911,870	24,485	1,050,107	28,699
Gem stones:				
Diamonds thousand carats	3,961	387,472	4,348	475,131
Emeralds do	242	5,518	365	10,644
Other	NA	46,655	NA	51,418
Graphite short tons	56,675	2,348	67,922	2,494

See footnotes at end of table.

Table 9.—U.S. imports for consumption of principal minerals and products—Continued

Mineral	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Nonmetals—Continued				
Gypsum:				
Crude, ground, calcined thousand short tons	[r] 4,565	$9,809	5,476	$11,473
Manufactures	NA	1,544	NA	1,585
Iodine, crude thousand pounds	3,459	3,177	5,883	5,594
Kyanite short tons	1,821	75	1,450	51
Lime:				
Hydrated do.	545	12	873	21
Other do.	79,983	961	71,632	877
Dead-burned dolomite [1] do.	42,413	1,832	33,498	1,552
Magnesium:				
Magnesite do.	127,955	7,612	131,640	8,489
Compounds do.	[r] 37,043	[r] 816	49,344	1,326
Mica:				
Uncut sheet and punch thousand pounds	1,733	1,990	1,491	1,539
Scrap do.	1,016	25	3,217	77
Manufactures do.	5,440	3,373	5,298	3,373
Mineral-earth pigments: Iron oxide pigments:				
Natural short tons	3,670	271	4,442	253
Synthetic do.	14,034	2,626	18,596	3,455
Ocher, crude and refined do.	236	16	126	8
Siennas, crude and refined do.	951	104	1,464	173
Umber, crude and refined do.	4,275	162	4,671	178
Vandyke do.	272	24	589	50
Nitrogen compounds (major), including urea thousand short tons	[r] 1,692	[r] 84,080	1,652	82,221
Phosphate, crude do.	139	3,261	116	2,679
Phosphatic fertilizers do.	105	6,167	44	2,222
Pigments and salts:				
Lead pigments and compounds short tons	[r] 30,669	[r] 6,576	32,004	6,950
Zinc pigments and compounds do.	18,988	3,404	20,838	4,152
Potash do.	[r] 2,929,050	[r] 73,649	3,671,973	78,573
Pumice:				
Crude or unmanufactured do.	5,702	49	9,436	69
Wholly or partly manufactured do.	240,273	580	302,240	736
Manufactures, n.s.p.f.	NA	22	NA	17
Quartz crystal (Brazilian pebble) pounds	1,049,544	730	1,180,153	607
Salt thousand short tons	2,843	8,541	3,456	11,487
Sand and gravel:				
Glass sand do.	44	159	25	144
Other sand and gravel do.	588	753	729	984
Sodium sulfate do.	[r] 289	[r] 4,508	305	5,108
Stone and whiting	NA	19,823	NA	24,628
Strontium: Mineral short tons	5,612	118	12,896	290
Sulfur and pyrites:				
Sulfur:				
Ores and other forms, n.e.s. thousand long tons	1,474	47,612	1,572	64,277
Pyrites do.	10	51	13	68
Talc: Unmanufactured short tons	15,361	653	24,313	973
Fuels:				
Carbon black:				
Acetylene pounds	5,784,814	987	5,343,923	915
Gas black and carbon black do.	330,910	56	2,351,312	173
Coal:				
Bituminous, slack, culm and lignite short tons	227,338	1,992	224,394	1,900
Briquets do.	17,422	260	2,891	44
Coke do.	92,001	1,704	94,085	1,904
Peat:				
Fertilizer grade do.	277,241	12,088	285,875	12,716
Poultry and stable grade do.	3,601	189	1,725	100
Petroleum:				
Crude oil thousand barrels	411,649	930,327	472,323	1,067,450
Gasoline do.	15,215	51,883	21,591	81,614
Special naphtha do.	375	780	1,399	3,442
Kerosine do.	33	93	190	568
Distillate fuel oil do.	18,492	50,483	36,558	103,094
Residual fuel oil do.	395,939	941,895	421,561	830,475
Military jet fuel do.	5,450	16,132	7,117	21,066
Commercial jet fuel do.	26,941	80,015	30,375	90,214
Liquefied gases do.	9,885	16,805	11,647	19,916
Asphalt do.	6,447	13,152	6,236	13,096
Unfinished oil do.	35,225	93,699	29,350	71,321
Lubricants do.	40	501	33	533
Wax do.	20	176	17	74
Petrochemical feed stocks do.	280	2,990	----------	----------
Total	XX	6,987,242	XX	8,483,473

[r] Revised. XX Not applicable.
NA Not available.

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.

Table 10.—Comparison of world [1] and United States production of principal metals and minerals

Mineral	1967			1968 [p]		
	World [r] [1]	United States		World [1]	United States	
	Thousand short tons (unless otherwise stated)		Percent of world	Thousand short tons (unless otherwise stated)		Percent of world
Fuels:						
Carbon black ---- thousand pounds	4,447,583	2,483,840	56	5,041,488	2,811,806	56
Coal:						
Bituminous	2,003,150	548,136	27	2,073,304	540,428	26
Lignite	792,472	4,490	(2)	812,799	4,817	(2)
Pennsylvania anthracite	200,736	12,255	6	200,335	11,461	6
Coke (excluding breeze):						
Gashouse [3]	20,472	163	1	15,585	174	1
Oven and beehive	334,522	[r] 64,580	20	315,272	63,653	20
Natural gas (marketable) ---- million cubic feet	28,408,525	18,171,325	64	31,028,664	19,322,400	62
Peat	218,576	617	(2)	211,222	619	(2)
Petroleum (crude) ---- thousand barrels	12,873,486	3,215,742	25	14,083,717	3,329,042	24
Nonmetals:						
Asbestos	[r] 3,095	123	4	NA	121	NA
Barite	[r] 3,820	944	25	3,915	[4] 927	24
Cement [5] ---- thousand 376-pound barrels	2,722,068	385,629	14	2,872,929	397,343	14
China clay	11,706	[6] 3,973	34	NA	[6] 4,201	NA
Corundum	11	----	----	NA	----	----
Diamonds ---- thousand carats	[r] 9,634	----	----	10,600	----	----
Diatomite	1,711	[7] 627	37	1,522	[7] 627	41
Feldspar ---- thousand long tons	[r] 1,974	615	31	NA	668	NA
Fluorspar	3,502	296	8	NA	252	NA
Graphite	396	W	NA	392	W	NA
Gypsum	52,145	9,393	18	NA	10,018	NA
Lime (sold or used by producers)	88,828	17,974	20	80,818	18,637	23
Magnesite	[r] 11,399	W	NA	11,145	W	NA
Mica (including scrap) ---- thousand pounds	[r] 317,097	237,026	75	337,524	250,661	74
Nitrogen, agricultural [5] [8]	24,442	6,237	26	27,818	6,872	25
Phosphate rock ---- thousand long tons	86,133	39,770	46	92,838	41,251	44
Potash (K_2O equivalent)	16,858	3,299	20	17,140	2,722	16
Pumice [9]	15,728	3,474	22	NA	3,551	NA
Pyrites ---- thousand long tons	21,856	861	4	21,737	872	4
Salt [5]	131,564	27,285	21	124,442	28,813	23
Strontium [9]	14	----	----	20	----	----
Sulfur, elemental ---- thousand long tons	17,597	8,270	47	18,604	8,814	47
Talc, pyrophyllite, and soapstone	[r] 4,352	903	21	4,738	958	20
Vermiculite [9]	370	255	69	417	290	70
Metals, mine basis:						
Antimony (content of ore and concentrate) ---- short tons	63,849	892	1	67,767	856	1
Arsenic, white [9]	65	W	NA	65	W	NA
Bauxite ---- thousand long tons	[r] 43,889	[10] 1,654	4	42,880	[10] 1,665	4
Beryllium concentrate ---- short tons	[r] 5,423	W	NA	6,116	168	3
Bismuth ---- thousand pounds	7,630	W	NA	7,589	W	NA
Cadmium ---- do	28,279	[11] 8,699	31	31,032	[11] 10,651	34

Chromite	4,720	------------	--------	5,206	------------	--------
Cobalt (contained) short tons	22	W	NA	22	W	NA
Columbium-tantalum concentrates [9] thousand pounds	21,052	W	NA	20,331	W	NA
Copper (content of ore and concentrate)	5,519	[12] 954	17	5,894	[12] 1,205	20
Gold thousand troy ounces	45,708	1,584	3	46,168	1,478	3
Iron ore thousand long tons	[r] 615,538	[13] 84,179	14	670,943	[13] 85,865	13
Lead (content of ore and concentrate)	3,169	[12] 317	10	3,309	[12] 359	11
Manganese ore (35 percent or more Mn)	18,375	13	(2)	19,194	11	(2)
Mercury thousand 76-pound flasks	[r] 233	24	10	255	29	11
Molybdenum (content of ore and concentrate) thousand pounds	[r] 126,416	[r] 90,097	71	[e] 125,673	93,477	74
Nickel (content of ore and concentrate)	486	15	3	529	15	3
Platinum groups (Pt., Pd., etc.) thousand troy ounces	3,170	16	1	3,415	15	(2)
Silver do	259,006	32,119	12	272,507	32,729	12
Tin (content of ore and concentrate) long tons	215,006	W	NA	226,624	W	NA
Titanium concentrates:						
Ilmenite [9]	[r] 3,019	935	31	3,216	979	30
Rutile [9]	[r] 337	W	NA	357	W	NA
Tungsten concentrate (contained tungsten) short tons	31,496	4,322	14	34,907	5,094	15
Vanadium (content of ore and concentrate) [9] do	[r] 10,509	4,963	47	12,562	6,483	52
Zinc (content of ore and concentrate)	5,331	549	10	5,436	529	10
Metals, smelter basis:						
Aluminum	8,352	3,269	39	8,864	3,255	37
Copper	5,939	[14] 862	15	6,649	[14] 1,266	19
Iron, pig (including ferroalloys)	392,317	89,479	23	391,451	91,345	23
Lead	3,058	[15] 380	12	3,221	[15] 467	14
Magnesium short tons	205,069	97,406	47	207,089	98,375	48
Selenium [9] thousand pounds	[r] 2,118	598	28	2,045	633	31
Steel ingots and castings	542,524	[16] 127,213	23	564,545	[16] 131,462	23
Tellurium [9] thousand pounds	284	135	48	270	121	45
Tin long tons	219,276	[17] [18] 3,048	1	230,021	[17] [18] 3,453	2
Uranium oxide (U_3O_8) [9] short tons	18,978	9,125	48	22,344	12,338	55
Zinc	4,550	939	21	5,017	1,021	20

---

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Total is not strictly comparable with previous years as it does not represent total world production. Confidential U.S. data are excluded. The data includes reported figures and reasonable estimates in some instances where data were not available no reasonable estimate could be made and none has been included except for gold, silver and pyrites.

[2] Less than ½ unit.

[3] Includes low- and medium-temperature and gashouse coke.

[4] Sold or used by producers.

[5] Including Puerto Rico.

[6] Kaolin sold or used by producers.

[7] Average annual production from the appropriate 3-year totals, 1963–65 and 1966–68.

[8] Year ended June 30 of year stated (United Nations).

[9] World total exclusive of U.S.S.R.

[10] Dry bauxite equivalent of crude ore.

[11] Including secondary.

[12] Recoverable.

[13] Iron-nickel ore.

[14] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1964, 1,301,107; 1965, 1,402,798; 1966, 1,429,854; 1967, 941,343; and 1968, 1,233,951.

[15] Lead refined from domestic and foreign ores, excludes lead refined from imported base bullion.

[16] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.

[17] U.S. imports of tin concentrates (tin content).

[18] Includes tin content of alloys made directly from ores.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/68

Injury Experience and Worktime in the Mineral Industries

By Forrest T. Moyer [1]

The overall safety record for the mineral mining and processing industries in 1968 was a slight improvement in nonfatal injury experience but a retrogression in fatality experience. The totals of 606 fatal and 31,060 nonfatal injuries occurred at respective frequency rates of 0.32 and 16.30 per million man-hours of worktime. The comparable data for 1967 were 512 fatal and 31,360 nonfatal injuries at respective frequencies of 0.27 and 16.83 per million man-hours.

The worsening of fatality experience in 1968 resulted primarily from three major disasters (a single accident which results in the death of five men or more) during the year. In March, a shaft fire at a Louisiana salt mine caused 21 fatalities; in August a dust explosion at a Kentucky coal mine resulted in nine deaths; and in November a gas and dust explosion at a West Virginia coal mine caused 78 fatalities.

Scope of Report.—These statistics comprise the injury and work experience of all personnel engaged in production, exploration, development, maintenance, repair, and force-account construction work, including supervisory and technical personnel, and working partners at mineral-producing and mineral-processing establishments in the United States. Data concerning office-workers are excluded except for the oil and gas industry for which such data are not separable.

The coverage of all industries is complete except for oil and gas in which coverage varies from year to year particularly with respect to small companies. The 1968 data were collected and compiled by the Division of Statistics with continued modification of procedures. These modifications affect only the figures on men working, days active, and man-days. All injury rates were calculated from unrounded data and in some instances cannot be reproduced from the rounded data shown in the tables.

Most of the information was reported by the producer or operator, but to obtain complete coverage it was necessary to estimate some worktime data for nonreporting plants, using information from other sources. Injury experience for these nonreporters was not estimated, but was projected from the aggregate injury experience of reporters in the same industry.

MINERALS

METAL MINES AND MILLS

All general measures of injury experience at metal mines were improved in 1968. The totals of 57 fatal and 2,830 nonfatal injuries were well below the corresponding figures for 1967. These smaller numbers of injuries, coupled with the increased man-hours of worktime, resulted in a frequency rate for all injuries of 29.16 per million man-hours in 1968, 5 percent lower than in the preceding year. The injury-severity rate of 4,898 days lost per million man-hours was 17 percent lower than in 1967, owing largely to the reduced number of fatalities.

There was a similar, but sharper, improvement in the safety record at metal mills in 1968. The one fatal and 535 nonfatal injuries were appreciably lower than in 1967. As worktime increased 8 percent in 1968, the frequency rate of all injuries decreased to 10.55 or 17 percent below

---

[1] Chief, Office of Accident Analysis, Office of Associate Director for Health and Safety.

1967. The injury-severity rate of 752 in 1968 was 49 percent lower than in 1967.

At copper mines in 1968, the 18 fatal and 605 nonfatal injuries had an overall rate of occurrence of 18.54 per million man-hours and a severity rate of 4,135 days lost per million man-hours. Each of these general measures of injury experience was improved over 1967 data. At copper mills, the number of fatalities was reduced to one, but nonfatal injuries increased to 135 in 1968. However, owing to the increased worktime, the frequency rate of 10.60 for all injuries in 1968 was virtually the same as in 1967. The injury-severity rate of 893 was substantially improved over that of 1967. The work stoppage at copper mines and mills which had started in mid-July 1967 was ended in March 1968. As a result, man-hours of work at mines and mills in 1968 were appreciably above 1967 levels.

The retrogression of the safety record at gold mines in 1968 was compensated only in part by an improvement at gold mills. The 10 fatal and 320 nonfatal injuries at the mines had a frequency rate of 46.93 and a severity rate of 11,773. Each of these measures was appreciably higher than in 1967. There were only five nonfatal injuries at gold mills with a rate of occurrence of 4.44 per million man-hours and a severity rate of 4,024.

At iron mines in 1968, the seven fatal and 465 nonfatal injuries were respectively four and 13 fewer than in 1967. However, owing to the reduced worktime, the frequency rate of all injuries increased slightly. The injury-severity rate of 2,368 days lost per million man-hours was improved over 1967. For iron-ore mills, injury experience was improved appreciably in 1968. There were no fatalities and the total of 135 nonfatal injuries was 14 fewer than in 1967. The reduced number of injuries, coupled with the marked increase in worktime, resulted in a frequency rate of 7.91 and a severity rate of 426 at iron mills in 1968.

The safety record of lead-zinc mines was more favorable than in 1967. There were two fewer fatal and 28 fewer nonfatal injuries in 1968. The injury-frequency and -severity rates, respectively 57.47 and 7,497, were lower than in 1967. Operating activity at the mines, as measured by man-hours worked, was at about the same level in 1968 as in the preceding year. At lead-zinc mills in 1968 there were no fatalities, but the total of 90 nonfatal injuries was 12 more than in 1967. As a result, the injury-frequency rate of 32.95 per million man-hours was less favorable than in the preceding year. The injury-severity rate of 2,249 was improved markedly over 1967 owing to the fatality-free year.

Operating activity at uranium mines in 1968 increased sharply over that during 1967. Although the total number of injuries in both years was nearly the same, the injury-frequency and -severity rates improved markedly. The six fatal and 310 nonfatal injuries at mines were, respectively, one more and two less than in 1967. At uranium mills in 1968, there were no fatalities and 35 nonfatal injuries, 21 less than in the preceding year. The smaller number of injuries, together with the increased worktime in 1968, resulted in a frequency rate of 9.67 and a severity rate of 85, both far below the corresponding rates in 1967.

At miscellaneous metal (molybdenum, titanium, mercury, bauxite, etc.) mines, the three fatalities and 245 nonfatal injuries were, respectively, five and 16 fewer than in 1967. However, the injury-frequency rate of 35.56 for 1968 was only slightly lower than in the preceding year, owing to the reduction in worktime. There was a sharp reduction in the severity rate to 4,935 in 1968 because of fewer fatalities. All measures of injury experience at mills processing the miscellaneous metal ores were improved in 1968. There were no fatalities and 135 nonfatal injuries compared with two fatal and 169 nonfatal injuries in 1967. The injury-frequency and injury-severity rates, respectively 10.05 and 692, were well below the corresponding data in 1967.

NONFERROUS REDUCTION AND REFINING PLANTS

The totals of four fatal and 1,155 nonfatal injuries at nonferrous smelting, reducing, and refining plants were, respectively, five fewer and 218 more than in 1967. With the reduced number of fatalities, the injury-severity rate of 725 in 1968 was sharply improved over that during the preceding year. However, the injury-frequency rate of 10.63 per million man-hours in 1968 was appreciably worse.

The frequency rate of injuries was improved slightly at lead and miscellaneous metal smelters in 1968, but was less favorable at copper, zinc, and aluminum reduction and refining plants. Primarily owing to improved fatality experience, the severity rates of injuries at copper, zinc, and miscellaneous metal plants were sharply better in 1968 than in the previous year. At lead and aluminum reduction plants, the injury-severity rates worsened in 1968.

Operating activity in 1968, as measured by man-hours worked, at copper and lead smelting and refining plants was appreciably higher than in the preceding year. The extended work stoppages affecting these plants were ended in March 1968. Activity at zinc, aluminum, and miscellaneous metal plants was lower than in 1967.

NONMETAL (EXCEPT STONE) MINES AND MILLS

The overall safety record of nonmetal mines worsened in 1968. The total of 991 injuries was 52 fewer than in 1967, but the injury-frequency rate for 1968 increased slightly to 27.30 per million man-hours because of the larger proportional decline in total worktime (table 4). The injury-severity rate of 7,068 days lost per million man-hours was more than double that for 1967 owing primarily to the larger number of fatalities, 36 compared with 17 in 1967. There was a major disaster in March 1968 from a shaft fire at a salt mine in which 21 men died.

At all mills processing nonmetals, the totals of four fatal and 1,515 nonfatal injuries were, respectively, nine and 10 fewer than in 1967 (table 5). However, the frequency rate of all injuries in 1968 increased slightly to 22.90 because of the decline in man-hours worked. The injury-severity rate of 1,209 days lost per million man-hours was improved sharply over that of 1967, owing principally to the lower number of fatalities.

All general measures of injury experience at clay-shale mines and mills were improved in 1968. The totals of fatal and nonfatal injuries, respectively, one and 175 at mines and two and 950 at mills, were lower than the corresponding figures for 1967. The resulting injury-frequency rates of 20.37 at mines and 30.65 at mills were more favorable than in 1967. With the reduced number of fatalities, the injury-severity rates in 1968 of 1,934 at mines and 1,472 at mills represented improvements over the similar data for the preceding years.

In the gypsum industry, the number of nonfatal injuries increased at both mines and mills and resulted in less favorable frequency rates of injuries in 1968. There was one fatality in both 1968 and 1967 at the mines, but none occurred at mills in either year. The severity rate of injuries was improved in 1968 at mines but was less favorable at the mills.

At both mines and mills in the phosphate rock industry, the frequency rates of injuries were higher in 1968, but the severity rates were improved over 1967 data. The higher frequency rate at mines resulted principally from an increased number of nonfatal injuries, whereas at mills the retrogression in injury frequency resulted primarily from the decline in man-hours worked. The improved severity rates resulted from the reduced numbers of fatalities in 1968.

The number of fatal and nonfatal injuries in 1968 at both potash mines and mills was lower than in 1967. However, the frequency rates of injuries at both locations were higher than in 1967 because of the reduction in man-hours worked. Owing to the lower numbers of fatalities in 1968 at mines and mills, the injury-severity rates were improved over those for 1967.

Injury experience in the salt industry worsened in 1968, as the number of fatal and nonfatal injuries increased at both mines and mills. At mines, the frequency rate of injuries was less favorable than in 1967, but at mills, the rate of occurrence was improved in 1968 because of the increased worktime. The injury-severity rates at both mines and mills were sharply higher than in 1967. Of the 24 fatalities at salt mines, 21 occurred in a major disaster on March 5, 1968, when a shaft fire at the Belle Isle Salt Mine, Cargill, Incorporated, Belle Isle, Louisiana, trapped the men underground.

Activity at sulfur mines, as measured by man-hours worked, increased moderately in 1968. There were no fatalities at the mines, but the nonfatal injuries increased to 85 or 31 more than in 1967. As a result, the injury-frequency rate worsened to 17.33 in 1968 whereas the severity rate improved to 932. There was no reported work activity at sulfur mills in 1968.

At miscellaneous nonmetal (barite, boron minerals, feldspar, fluorite, mica, talc, etc.) mines, fatalities increased to six, but nonfatal injuries decreased sharply to 180 in 1968. The resulting frequency rate of injuries of 32.19 improved moderately, whereas the severity rate worsened appreciably over the corresponding data for 1967. At mills, the totals of one fatal and 275 nonfatal injuries were, respectively, three fewer and 33 more than in 1967. The injury-frequency rate increased to 18.03, but the severity rate of 1,264 represented a substantial improvement over the comparable rates for 1967.

STONE QUARRIES AND MILLS

The overall frequency rate of injuries at all stone operations was virtually the same in 1968 as in 1967 inasmuch as there was little change in the total number of injuries and total worktime. However, fatalities were increased by 12 to a total of 58 in 1968 with the result that the injury-severity rate worsened to 2,702 days lost per million man-hours in 1968 (table 6).

All general measures of injury experience at cement quarries and mills retrogressed in 1968. The totals of 10 fatal and 380 nonfatal injuries were, respectively, six and 33 more than in 1967. As a result, both the frequency rate of 6.94 and the severity rate of 1,573 were worse than in the previous year.

At granite quarries and mills, fatalities increased by one to a total of four in 1968 with the result that the injury-severity rate was less favorable than in 1967. However, as nonfatal injuries decreased by 16 in 1968, the frequency rate of all injuries declined to 23.50.

At lime operations, the total of five fatalities was the same as in 1967 but the nonfatal injuries decreased by 25 to 260 in 1968. Consequently, the injury-frequency and injury-severity rates, respectively 15.28 and 2,108, were improved moderately over 1967 rates.

All general measures of injury experience at limestone quarries and mills were less favorable in 1968. The totals of 29 fatal and 1,445 nonfatal injuries were, respectively, three and 16 more than in 1967. The resulting injury-frequency rate of 22.57 and the severity rate of 3,526 were both higher than in 1967.

There were no fatalities at marble quarries and mills in either 1968 or 1967. For nonfatal injuries, the total of 175 for 1968 was 14 less than in the preceding year. As a result, the injury-frequency rate for 1968 was improved to 30.09. However, the injury-severity rate of 2,134 in 1968 worsened appreciably over that for 1967.

Fatality experience worsened sharply at sandstone operations and there were six fatalities in 1968 compared with none in the preceding year. Consequently, the injury-severity rate of 4,403 was more than seven times higher than in 1967. The frequency rate of all injuries rose slightly to 24.65 per million man-hours in 1968.

The safety record of slate quarries and mills was improved in 1968. There were no fatalities compared with three in 1967, and the number of nonfatal injuries was 10 less than in the preceding year. The injury-severity rate dropped sharply to 573 days lost per million man-hours and the frequency rate improved moderately to 31.30 in 1968.

At traprock operations, the totals of two fatal and 220 nonfatal injuries were respectively two fewer and 10 more than in 1967. The resulting injury-severity rate of 2,747 was moderately improved but the frequency rate of 24.32 was slightly less favorable compared with the corresponding data for 1967.

At miscellaneous stone quarries and mills, the totals of two fatal and 75 nonfatal injuries were, respectively, one and 11 more than in 1967. As a result the injury-severity rate worsened appreciably to 3,794 in 1968. However, the frequency rate of injuries improved slightly to 19.91 in 1968, owing to the greater worktime.

SAND AND GRAVEL OPERATIONS

Fatality experience in the sand and gravel industry was improved and the total of 25 deaths was seven fewer than in 1967. Consequently, the injury-severity rate of 2,626 in 1968 represented a moderate improvement over that for 1967 (table 7). However, nonfatal injuries increased by 71 to a total of 1,990 in 1968. This increase coupled with the decreased worktime resulted in a frequency rate of 21.65 for all injuries, a moderate retrogression from the 1967 rate.

SLAG (IRON-BLAST-FURNACE) OPERATIONS

The safety record of the slag industry was improved in 1968. There were two fewer fatalities in 1968 and the injury-severity rate of 2,454 days lost per million man-hours was less than half the corresponding rate in 1967. The frequency rate of 15.69 for all injuries in 1968 was slightly lower than in the preceding year.

MINERAL FUELS

The totals of 420 fatal and 18,764 nonfatal work injuries in 1968 were, respectively, 101 more and 401 less than in the preceding year. As a result, the fatality frequency rate of 0.33 per million man-hours was sharply higher than that of 0.26 in 1967. For nonfatal injuries, the frequency rate of 14.89 in 1968 represented a slight improvement over the corresponding rate of 15.69 in the preceding year. The worsened fatality experience in 1968 resulted primarily from the two major disasters in bituminous-coal mining.

COAL MINES

The safety record of the coal mining industry worsened appreciably in fatality experience but improved slightly in nonfatal injury experience. Fatalities in 1968 totaled 311 or 89 more than in 1967 (table 9). The resulting severity rate of 10,071 days lost per million man-hours was markedly higher than in the preceding year and was the highest annual rate since 1963. There were two major disasters in 1968 with a death toll of 87, whereas in 1967 there were no major disasters.

The total of 9,460 nonfatal work injuries was 655 less than in 1967 and was the lowest annual figure in complete records back to 1930. Owing to the lower number of injuries, the frequency rate of all injuries improved slightly to 41.68 per million man-hours and was the lowest annual rate in a statistical history started in 1930.

Injury and worktime statistics for 1968 are based on final data for anthracite mines and preliminary data for bituminous-coal and lignite mines.

Bituminous-Coal and Lignite Mines.—Fatality experience in bituminous-coal and lignite mines retrogressed markedly in 1968. The total of 307 fatal injuries, 94 more than in 1967, was the highest annual figure since 1958. Owing to the increased number of fatal injuries, the severity rate of 10,361 days lost per million man-hours of worktime in 1968 was appreciably higher than in the preceding year. The worsened fatality experience in 1968 resulted primarily from two major disasters (a single accident which results in the death of five men or more). A dust explosion, initiated by improper handling of explosives in the underground workings of the River Queen No. 1 Mine, Peabody Coal Company, Greenville, Kentucky, on August 7, 1968, claimed the lives of nine men, and a gas and dust explosion in the Consol No. 9 Mine, Mountaineer Coal Company, Division of Consolidation Coal Company, Farmington, West Virginia, on November 20, 1968, claimed 78 lives. There were no major disasters in coal mines during 1967.

By work locations, the fatalities in 1968 were distributed as follows: Underground workings, 267; associated surface of underground mines, eight; strip mines, 22; auger mines, six; and mechanical cleaning plants, four. Of the fatal injuries in underground workings, the following were the ranking causes of accidents: Falls of roof, face, or side (98 deaths), gas and dust explosions (88), haulage (31), electricity (17), and machinery (15 deaths).

The total of 8,955 nonfatal injuries in 1968 was 551 less than in 1967. Owing to the larger proportional decline in injuries than in man-hours, the frequency rate of 41.46 per million man-hours for all injuries represented a slight improvement over the similar rate of 42.36 for the preceding year.

Anthracite Mines.—Fatality experience at Pennsylvania anthracite mines was better than in any other year of statistical history. The total of four fatalities in 1968 was five less than in 1967. There also was a decline in the number of nonfatal injuries to a total of 504 in 1968, 105 less than in the preceding year. As a result, both the injury-frequency and injury-severity rates in 1968, respectively 46.13 and 4,182, were improved sharply over the corresponding rates of 50.00 and 5,511 for 1967.

COKE OPERATIONS

The overall safety record at coke operations in 1968 was a slight improvement in the injury-frequency rate to 5.62 per million man-hours but a worsening in the injury-severity rate to 1,875 days lost per million man-hours (table 10). The total of seven fatalities was two fewer and for nonfatal injuries the total of 204 was 22 less than in 1967.

Slot Ovens.—Fatality experience worsened at slot-oven plants in 1968. The total of seven fatalities was two more than in 1967 and as a result the injury-severity rate increased sharply to 1,876. The injury-frequency rate of 5.14 represented a slight improvement over 1967, owing to the lower number of nonfatal injuries, 184 in 1968.

Beehive Ovens.—There were no fatalities at beehive-oven plants in 1968, compared with four in the preceding year. The total of 20 nonfatal injuries was five fewer than in 1967. Both the injury-frequency and injury-severity rates, respectively 52.85 and 1,855, were well below the corresponding rates for 1967.

OIL AND GAS OPERATIONS

The totals of 102 fatal and 9,069 nonfatal injuries in the oil and gas industries during 1968 were, respectively, 14 and 293 more than in 1967 (table 11). However, there was a moderate increase in worktime to a total of nearly 987 million man-hours in 1968. Consequently, the injury-frequency rate of 9.29 was slightly improved over 1967, and the injury-severity rate of 985 was virtually unchanged from that of the preceding year.

PEAT

The safety record of the peat industry was improved in 1968. There were no fatalities in either 1968 or 1967 and the eight nonfatal injuries were seven fewer than the total for 1967. As a result, both the injury-frequency and injury-severity rates, respectively 10.02 and 244, were appreciably more favorable than in 1967.

NATIVE ASPHALT

Injury experience in the native asphalt industry (bituminous limestone, bituminous sandstone, and gilsonite operations) was better than in 1967. There were no fatalities in either 1968 or 1967 and the total of 23 nonfatal injuries was 10 less than in 1967. Consequently, the injury-frequency rate of 27.49 and the injury-severity rate of 672 were far below the corresponding rates for 1967.

Table 1.—Worktime and injury experience at metal mines in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Copper:								
1964	15,820	288	4,549	36,323	13	1,034	28.82	3,468
1965	16,880	298	5,033	40,285	19	896	22.71	4,348
1966	16,278	317	5,164	41,323	23	976	24.18	4,856
1967	17,258	218	3,760	30,064	19	654	22.39	5,520
1968 p	15,500	267	4,183	33,555	18	605	18.54	4,135
Gold-silver (lode-placer):								
1964	4,312	228	983	7,885	4	208	26.89	3,956
1965	4,074	241	982	7,896	4	264	33.94	5,970
1966	3,847	236	907	7,254	10	305	43.42	9,846
1967	3,611	237	855	6,844	8	263	39.60	10,022
1968 p	3,900	223	882	7,055	10	320	46.93	11,773
Iron:								
1964	14,189	258	3,659	29,443	12	452	15.76	3,309
1965	14,439	273	3,942	31,752	5	510	16.22	1,727
1966	14,056	277	3,898	31,860	13	553	18.05	3,526
1967	12,772	282	3,600	28,859	11	478	16.94	2,846
1968 p	11,900	285	3,415	27,390	7	465	17.16	2,868
Lead-zinc:								
1964	8,158	260	2,118	16,969	19	1,038	62.29	10,113
1965	8,805	259	2,279	18,240	17	1,089	60.64	8,128
1966	8,692	261	2,273	18,212	15	1,096	61.00	8,108
1967	7,781	252	1,962	15,727	15	913	59.01	8,563
1968 p	7,500	258	1,959	15,660	13	885	57.47	7,497
Uranium:								
1964	4,772	203	969	7,833	4	349	45.07	6,401
1965	3,654	211	771	6,205	10	282	47.06	12,144
1966	3,604	204	735	5,945	7	210	36.50	8,845
1967	3,745	223	834	6,751	5	312	46.95	7,139
1968 p	4,500	219	1,003	8,385	6	310	37.80	5,542
Miscellaneous:								
1964	2,514	286	718	5,750	3	185	32.69	4,755
1965	3,568	r 277	987	7,898	3	251	32.16	3,467
1966	3,448	281	967	7,762	7	295	38.91	7,555
1967	3,329	283	943	7,549	8	261	35.64	8,455
1968 p	3,000	285	864	6,915	3	245	35.56	4,935
Total: [1]								
1964	49,765	261	12,996	104,204	55	3,266	31.87	4,833
1965	51,420	272	13,994	112,277	58	3,292	29.84	4,704
1966	49,920	279	13,944	111,857	75	3,435	31.38	5,786
1967	48,496	246	11,953	95,794	66	2,881	30.76	5,881
1968 p	46,800	263	12,306	98,960	57	2,830	29.16	4,898

p Preliminary. r Revised.

[1] Data may not add to totals shown because of rounding.

Table 2.—Worktime and injury experience at metal mills in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Copper:								
1964	5,062	316	1,600	12,800	1	89	7.03	883
1965	5,190	335	1,737	13,897	------	90	6.48	364
1966	5,369	344	1,847	14,765	------	75	5.08	394
1967	5,953	228	1,358	10,863	3	112	10.59	2,106
1968 p	5,600	286	1,628	13,025	1	135	10.60	893
Gold-silver (lode-placer):								
1964	318	282	90	716	------	13	18.14	361
1965	388	r 257	100	798	------	24	30.09	563
1966	406	287	117	984	1	31	34.26	8,479
1967	347	283	98	786	------	23	29.26	4,877
1968 p	400	288	113	900	------	5	4.44	4,024
Iron:								
1964	5,534	298	1,622	12,944	1	103	8.03	719
1965	6,334	288	1,823	14,651	1	121	8.33	718
1966	6,293	299	1,881	15,090	3	117	7.95	1,615
1967	6,137	305	1,875	15,032	1	149	9.98	1,049
1968 p	6,600	321	2,129	17,070	------	135	7.91	426
Lead-zinc:								
1964	1,285	267	343	2,731	1	46	17.21	2,883
1965	1,271	278	353	2,825	2	76	27.61	5,061
1966	1,449	268	389	3,104	------	77	24.81	2,290
1967	1,410	251	354	2,835	1	78	27.86	3,430
1968 p	1,200	264	333	2,670	------	90	32.95	2,249
Uranium:								
1964	1,441	300	432	3,560	1	59	16.85	2,142
1965	1,248	313	391	3,112	------	71	22.81	1,713
1966	1,420	297	422	3,398	------	69	20.31	1,291
1967	1,518	281	427	3,419	------	56	16.38	842
1968 p	1,500	297	447	3,620	------	35	9.67	85
Miscellaneous:								
1964	4,735	329	1,560	12,492	1	96	7.77	873
1965	5,053	331	1,671	13,373	------	90	6.73	221
1966	5,238	325	1,701	13,760	3	206	15.19	2,192
1967	5,563	315	1,752	14,015	2	169	12.20	1,176
1968 p	5,400	313	1,679	13,430	------	135	10.05	692
Total: [1]								
1964	18,375	307	5,646	45,243	5	406	9.08	1,045
1965	19,484	312	6,074	48,657	3	472	9.76	798
1966	20,175	315	6,357	51,050	7	575	11.40	1,563
1967	20,928	280	5,863	46,951	7	587	12.65	1,488
1968 p	20,700	304	6,328	50,715	1	535	10.55	752

p Preliminary. r Revised.

[1] Data may not add to totals shown because of rounding.

Table 3.—Worktime and injury experience at primary nonferrous reduction and refinery plants in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Copper:								
1964	10,495	323	3,385	27,106	1	355	13.13	751
1965	10,875	334	3,635	29,060	3	314	10.91	1,257
1966	10,411	335	3,486	27,779	5	362	13.21	1,673
1967	10,750	226	2,434	19,471	2	260	13.46	1,219
1968 p	10,300	291	2,993	23,910	1	340	14.13	991
Lead:								
1964	2,327	321	746	6,002	1	67	11.33	2,353
1965	2,326	301	701	5,608	1	74	13.37	2,897
1966	2,508	317	795	6,360	3	105	16.98	3,392
1967	2,031	289	587	4,679	------	110	23.51	1,546
1968 p	2,400	293	693	5,545	1	125	22.91	2,434
Zinc:								
1964	6,848	334	2,284	18,064	3	314	17.55	1,622
1965	7,128	340	2,426	18,971	4	284	15.18	1,897
1966	7,086	330	2,337	18,432	1	338	18.39	895
1967	7,280	316	2,304	18.426	5	289	15.96	2,493
1968 p	6,700	334	2,246	17,970	------	335	18.64	742
Aluminum:								
1964	15,794	334	5,278	42,917	3	242	5.71	790
1965	19,582	343	6,712	52,048	3	278	5.40	629
1966	18,872	348	6,393	50,986	------	228	4.47	368
1967	20,508	347	7,107	56,854	1	245	4.33	439
1968 p	20,100	346	6,937	55,805	2	325	5.84	468
Miscellaneous:								
1964	1,492	312	465	3,719	------	21	5.65	155
1965	1,716	283	485	3,880	1	21	5.67	1,795
1966	2,024	351	711	5,699	------	34	5.97	763
1967	2,477	307	761	6,081	1	33	5.59	1,093
1968 p	2,100	344	720	5,785	------	30	5.53	421
Total: [1]								
1964	36,956	329	12,158	97,807	8	999	10.30	1,005
1965	41,627	335	13,959	109,567	12	971	8.97	1,173
1966	40,401	340	13,722	109,257	9	1,067	9.85	985
1967	43,046	307	13,194	105,511	9	937	8.97	1,029
1968 p	41,600	327	13,590	109,010	4	1,155	10.63	725

p Preliminary.

[1] Data may not add to totals shown because of rounding.

Table 4.—Worktime and injury experience at nonmetal (except stone) mines in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Clay-shale:								
1964	5,450	212	1,156	9,366	7	254	27.87	6,169
1965	5,544	220	1,217	9,877	4	291	29.87	4,084
1966	5,776	219	1,266	10,316	2	281	27.43	2,147
1967	5,213	227	1,182	9,607	2	247	25.92	1,967
1968 p	4,700	219	1,056	8,590	1	175	20.37	1,934
Gypsum:								
1964	1,019	255	260	2,091	------	15	7.17	302
1965	970	255	247	2,001	2	19	10.49	6,439
1966	935	244	228	1,848	------	23	12.45	3,748
1967	891	249	222	1,799	1	12	7.23	3,628
1968 p	900	254	228	1,840	1	20	10.88	3,518
Phosphate rock:								
1964	2,124	296	629	5,063	2	92	18.57	3,410
1965	2,507	294	738	5,962	2	122	20.80	2,460
1966	3,188	302	960	7,791	5	161	21.31	4,329
1967	3,181	272	865	6,991	3	160	23.32	3,554
1968 p	3,000	278	827	6,700	2	165	24.63	2,476
Potash:								
1964	2,022	333	673	5,384	4	171	32.50	6,138
1965	1,753	357	625	5,004	1	192	38.57	4,334
1966	1,934	357	690	5,516	4	209	38.61	5,663
1967	1,913	328	627	5,017	3	163	33.09	4,718
1968 p	1,600	326	531	4,245	2	155	37.45	3,495
Salt:								
1964	1,551	273	423	3,487	1	122	35.27	4,335
1965	1,638	279	457	3,745	3	97	26.70	7,103
1966	1,809	279	504	4,104	2	90	22.42	4,371
1967	1,768	266	470	3,892	2	168	43.68	4.318
1968 p	1,900	274	511	4,175	24	175	47.92	37,205
Sulfur:								
1964	1,313	363	476	4,106	------	53	12.91	418
1965	1,371	363	497	4,466	2	55	12.76	3,073
1966	1,491	360	537	4,632	------	54	11.66	1,985
1967	1,640	365	598	4,783	2	54	11.71	2,878
1968 p	1,600	348	562	4,965	------	85	17.38	932
Miscellaneous:								
1964	3,608	223	808	6,479	4	199	31.33	4,993
1965	3,431	242	831	6,706	7	213	32.81	9,127
1966	3,599	234	841	6,796	3	240	35.76	3,810
1967	3,414	235	801	6,461	4	222	34.98	4,709
1968 p	3,000	238	710	5,715	6	180	32.19	7,285
Total: [1]								
1964	17,087	259	4,420	35,977	18	906	25.68	4,389
1965	17,214	268	4,612	r 37,760	21	989	26.75	5,048
1966	18,727	268	5,027	41,008	16	1,058	26.19	3,586
1967	18,020	264	4,765	38,550	17	1,026	27.06	3,499
1968 p	16,700	268	4,424	36,225	36	955	27.30	7,068

p Preliminary. r Revised.

[1] Data may not add to totals shown because of rounding.

Table 5.—Worktime and injury experience at nonmetal (except stone) mills in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Clay-shale:								
1964	15,250	261	3,982	32,058	4	1,011	31.66	2,025
1965	14,136	264	3,738	30,116	5	890	29.72	2,047
1966	15,603	270	4,214	34,028	3	1,020	30.06	2,101
1967	15,874	256	4,068	32,742	6	1,007	30.94	2,172
1968 [p]	14,500	265	3,861	31,030	2	950	30.65	1,472
Gypsum: [1]								
1964	1,589	278	442	3,467	------	20	5.77	1,804
1965	2,890	283	817	6,557	------	25	3.81	588
1966	2,589	269	696	5,557	1	21	3.96	1,721
1967	2,094	265	555	4,473	------	15	3.35	163
1968 [p]	2,000	267	527	4,300	------	20	4.88	231
Phosphate rock:								
1964	2,163	319	690	5,514	------	38	6.89	1,017
1965	2,476	312	773	6,198	4	54	9.36	5,194
1966	1,948	335	653	5,237	3	60	12.03	3,821
1967	2,042	297	607	4,854	1	55	11.54	3,420
1968 [p]	1,700	306	526	4,210	------	55	13.06	579
Potash:								
1964	1,003	332	333	2,666	1	45	17.25	2,644
1965	1,126	357	402	3,214	------	72	22.40	1,959
1966	1,030	360	371	2,967	------	47	15.84	2,028
1967	992	347	344	2,751	2	49	18.54	4,921
1968 [p]	600	309	208	1,625	------	40	25.85	702
Salt:								
1964	4,870	[r] 288	1,405	11,229	------	183	16.30	657
1965	3,909	284	1,109	8,967	------	154	17.17	867
1966	3,814	292	1,112	8,898	2	162	18.43	1,787
1967	3,704	283	1,047	8,393	------	156	18.59	448
1968 [p]	4,100	294	1,207	9,700	1	170	17.63	1,073
Sulfur:								
1964	11	[r] 237	3	21	------	--------	--------	--------
1965	10	[r] 305	3	24	------	2	[r] 81.97	[r] 82
1966	2	300	1	5	------	--------	--------	--------
1967	1	250	(3)	2	------	1	500.00	12,500
1968 [p]	------	------	--------	--------	------	--------	--------	--------
Miscellaneous:								
1964	7,081	291	2,060	16,506	1	283	17.21	1,185
1965	6,668	296	1,976	15,898	1	286	18.05	1,840
1966	7,015	286	2,006	16,118	2	254	15.88	1,541
1967	6,720	289	1,944	15,635	4	242	15.73	2,232
1968 [p]	6,900	278	1,913	15,365	1	275	18.03	1,264
Total: [2]								
1964	31,967	279	8,914	71,461	6	1,580	22.19	1,550
1965	31,215	283	8,819	70,975	10	1,483	21.04	1,987
1966	32,001	283	9,052	72,810	11	1,564	21.63	2,030
1967	31,427	273	8,565	68,850	13	1,525	22.34	2,043
1968 [p]	29,800	276	8,237	66,235	4	1,515	22.90	1,209

[p] Preliminary. [r] Revised.

[1] Beginning with 1965, includes data on certain mills not reported in prior years.

[2] Data may not add to totals shown because of rounding.

[3] Less than 500.

Table 6.—Worktime and injury experience at stone quarries and mills in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Cement: [1]								
1964	23,017	318	7,323	58,592	8	303	5.31	1,017
1965	22,947	319	7,322	58,563	10	331	5.82	1,399
1966	22,611	326	7,381	59,044	6	359	6.18	1,245
1967	22,073	317	7,008	56,119	4	347	6.25	1,140
1968 p	21,800	320	6,984	55,890	10	380	6.94	1,573
Granite:								
1964	8,743	236	2,065	17,076	6	466	27.64	3,753
1965	8,956	243	2,176	18,284	6	409	22.70	2,966
1966	8,141	246	2,005	16,756	2	412	24.71	3,069
1967	7,853	249	1,958	16,351	3	401	24.71	2,296
1968 p	8,000	246	1,962	16,515	4	385	23.50	3,155
Lime: [1]								
1964	6,956	304	2,117	17,026	5	296	17.68	2,310
1965	7,671	291	2,234	17,958	4	282	15.93	1,808
1966	7,467	299	2,236	18,039	6	345	19.46	3,269
1967	7,764	282	2,190	17,583	5	285	16.49	2,417
1968 p	7,500	283	2,134	17,210	5	260	15.28	2,108
Limestone:								
1964	31,660	236	7,482	63,476	34	1,424	22.97	4,468
1965	32,872	240	7,904	67,038	21	1,448	21.91	3,182
1966	30,380	245	7,434	63,422	30	1,542	24.79	4,385
1967	31,145	245	7,619	64,907	26	1,429	22.42	3,327
1968 p	30,800	248	7,646	65,340	29	1,445	22.57	3,526
Marble:								
1964	2,602	258	671	5,456	------	174	31.89	581
1965	2,534	249	631	5,165	2	181	35.43	3,308
1966	2,953	255	753	6,178	1	213	34.64	2,528
1967	2,894	251	725	6,080	------	189	31.09	1,115
1968 p	2,800	246	691	5,780	------	175	30.09	2,134
Sandstone:								
1964	5,427	221	1,197	9,779	4	282	29.24	3,180
1965	5,745	227	1,305	10,696	4	278	26.36	3,192
1966	5,447	240	1,308	10,895	3	314	29.10	2,739
1967	5,012	241	1,209	10,047	------	242	24.09	622
1968 p	5,100	232	1,194	9,860	6	235	24.65	4,408
Slate:								
1964	1,402	263	369	2,993	1	86	29.07	3,035
1965	1,232	262	322	2,630	------	84	31.93	723
1966	1,376	266	366	2,975	1	79	26.89	2,762
1967	1,423	260	371	3,024	3	100	34.06	6,611
1968 p	1,400	261	360	2,905	------	90	31.30	573
Traprock:								
1964	5,417	208	1,125	9,401	2	240	25.74	2,285
1965	5,530	213	1,180	9,855	1	215	21.92	1,166
1966	5,562	221	1,231	10,263	1	241	23.58	1,975
1967	4,794	224	1,075	8,940	4	210	23.94	3,281
1968 p	4,500	242	1,092	9,045	2	220	24.32	2,747
Miscellaneous:								
1964	2,635	199	525	4,200	1	96	23.10	1,799
1965	2,093	220	460	3,811	------	77	20.21	1,416
1966	1,889	211	398	3,216	1	78	24.56	2,528
1967	1,807	217	393	3,176	1	64	20.47	2,333
1968 p	2,000	227	462	3,920	2	75	19.91	3,794
Total: [2]								
1964	87,859	260	22,873	188,000	61	3,367	18.23	2,761
1965	89,580	263	23,585	194,000	48	3,305	17.28	2,830
1966	85,826	269	23,113	190,787	51	3,583	19.05	2,852
1967	84,765	266	22,548	186,227	46	3,267	17.79	2,308
1968	84,000	268	22,524	186,465	58	3,260	17.80	2,702

p Preliminary.
[1] Includes burning or calcining and other mill operations.
[2] Data may not add to totals shown because of rounding.

Table 7.—Worktime and injury experience at sand and gravel plants in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1964	55,886	217	12,129	100,891	34	1,957	19.73	3,237
1965	54,159	221	11,947	100,083	40	1,870	19.08	3,214
1966	55,344	225	12,459	104,971	35	2,098	20.32	2,901
1967	52,363	216	11,296	96,645	32	1,919	20.19	2,938
1968 [p]	49,900	219	10,948	93,155	25	1,990	21.65	2,626

[p] Preliminary.

Table 8.—Worktime and injury experience at slag (iron-blast-furnace) plants in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1964	1,472	264	389	3,107	1	53	17.38	3,895
1965	1,537	277	425	3,415	1	50	14.93	3,173
1966	1,472	277	407	3,332	------	44	13.20	709
1967	1,721	255	439	3,539	3	53	15.82	5,762
1968	1,724	268	454	3,697	1	57	15.69	2,454

Table 9.—Worktime and injury experience at coal mines and preparation plants in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Bituminous coal and lignite mines:								
1964	137,617	212	29,200	232,087	218	9,728	42.86	8,312
1965	137,602	213	29,242	232,613	251	10,071	44.37	9,243
1966	135,952	213	28,928	230,087	227	9,617	42.78	7,900
1967	131,562	220	28,910	229,415	218	9,506	42.36	7,817
1968 [p]	129,900	216	28,091	223,370	307	8,955	41.46	10,361
Anthracite mines:								
1964	13,144	214	2,812	20,368	24	1,342	67.07	9,650
1965	11,132	204	2,271	16,375	8	1,067	65.65	4,936
1966	9,292	203	1,883	13,672	6	829	61.07	4,477
1967	7,750	219	1,701	12,359	9	609	50.00	5,511
1968	6,932	217	1,508	11,011	4	504	46.13	4,182
Total: [1]								
1964	150,761	212	32,012	252,405	242	11,070	44.82	8,420
1965	148,734	212	31,513	248,988	259	11,138	45.77	8,960
1966	145,244	212	30,811	243,759	233	10,446	43.81	7,708
1967	139,312	220	30,611	241,774	222	10,115	42.75	7,699
1968 [p]	136,800	216	29,598	234,885	311	9,460	41.68	10,071

[p] Preliminary.

[1] Data may not add to totals shown because of rounding.

Table 10.—Worktime and injury experience at coke ovens in the United States, by industry groups

Industry and year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
Slot ovens:								
1964	13,021	362	4,718	37,675	1	164	4.38	703
1965	14,003	357	4,998	39,984	7	192	4.98	1,816
1966	13,745	363	4,983	39,909	3	155	3.96	658
1967	13,409	360	4,821	38,583	5	201	5.34	963
1968	12,877	361	4,645	37,167	7	184	5.14	1,876
Beehive ovens:								
1964	426	220	94	743	------	40	53.83	5,457
1965	518	222	115	885	------	36	40.68	1,318
1966	471	236	111	821	------	36	43.82	1,048
1967	292	179	52	374	4	25	77.61	67,561
1968	216	233	50	378	------	20	52.85	1,855
Total: [1]								
1964	13,447	357	4,807	38,418	1	204	5.34	795
1965	14,521	352	5,113	40,869	7	228	5.75	1,805
1966	14,216	358	5,094	40,730	3	191	4.76	666
1967	13,701	356	4,873	38,956	9	226	6.03	1,602
1968	13,093	359	4,696	37,546	7	204	5.62	1,875

[1] Data may not add to totals shown because of rounding.

Table 11.—Worktime and injury experience of the oil industry (all activities) and the natural gas industry (excluding distribution activities) in the United States

Year	Average men working daily	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
			Fatal	Nonfatal	Frequency	Severity
1964	427,697	910,525	109	8,551	9.51	1,172
1965	436,935	931,645	78	8,963	9.70	934
1966	451,747	954,527	103	8,724	9.25	1,050
1967	445,562	938,946	88	8,776	9.44	981
1968	466,652	986,952	102	9,069	9.29	985

Table 12.—Worktime and injury experience in the peat industry in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1964	781	170	133	1,122	------	24	21.39	1,851
1965	628	150	94	784	------	13	16.57	593
1966	523	184	96	804	------	10	12.44	373
1967	506	187	95	785	------	15	19.11	783
1968	533	186	99	798	------	8	10.02	244

Table 13.—Worktime and injury experience in the native asphalt industry (bituminous limestone, bituminous sandstone, and gilsonite mines and mills) in the United States

Year	Average men working daily	Average days active	Man-days worked (thousands)	Man-hours worked (thousands)	Number of injuries		Injury rates per million man-hours	
					Fatal	Nonfatal	Frequency	Severity
1964	369	256	94	762	2	30	41.97	16,701
1965	427	253	108	874	1	26	30.90	8,335
1966	368	270	99	806	1	28	35.98	7,872
1967	393	255	100	821	------	33	40.21	2,985
1968	399	259	103	837	------	23	27.49	672

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/106

Abrasive Materials

By J. Robert Wells [1]

The 1968 domestic output of natural abrasive materials, as measured by the quantities sold or used by producers, was the greatest on record. A decline in emery production was more than offset by substantial increases for both garnet and special silica-stone products, and even more notably, for tripoli, the quantities of which used for abrasive and nonabrasive purposes advanced significantly and nearly in equal proportion. The volume of production of crude artificial nonmetallic abrasives in the United States and Canada was virtually the same as in the previous year, although the total value was 8 percent higher. Output of artificial metallic abrasives showed a moderate advance in both quantity and total value. Shipments of corundum from Southern Rhodesia were cut off by the midyear imposition of a strict United Nations embargo on goods from that nation. Initial steps were taken to secure Congressional approval for the gradual disposal of some 18 million carats of industrial diamond now on Government inventory but declared surplus to the stockpile requirement.

Table 1.—Salient abrasive statistics in the United States

Kind	1964	1965	1966	1967	1968
Natural abrasives (domestic) sold or used by producers:					
Tripoli short tons	64,618	71,138	66,168	70,984	85,534
Value thousands	$268	$381	$328	$377	$796
Special silica-stone products [1] short tons	3,186	3,603	3,806	2,701	3,141
Value thousands	$292	$432	$515	$574	$629
Garnet short tons	16,128	19,330	21,952	20,494	22,136
Value thousands	$1,622	$1,717	$2,092	$1,849	$1,922
Emery short tons	9,214	10,720	11,102	W	W
Value thousands	$172	$204	$210	W	W
Artificial abrasives [2] short tons	459,169	524,305	607,508	552,812	567,814
Value thousands	$63,370	$73,102	$82,794	$80,405	$86,316
Foreign trade (natural and artificial abrasives):					
Exports (value) thousands	$43,455	$50,418	$51,753	$50,896	$60,266
Reexports (value) do	$17,142	$18,750	$18,148	$17,289	$19,807
Imports for consumption (value) thousands	$89,299	$89,332	$110,650	$100,427	$103,125

W Withheld to avoid disclosing individual company confidential data.

[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners, and whetstones.

[2] Production of silicon carbide and aluminum oxide (United States and Canada); shipments of metallic abrasives (United States).

Foreign Trade.—Although imports of nearly all the various categories of abrasive materials were somewhat greater than in 1967, the figure for net imports (total imports minus exports and reexports) was the lowest in at least 15 years, down 29 percent from the 1967 figure and 50 percent from that in 1966. Increases in exports and reexports of industrial diamond were the most evident influences in this reduction of the import-export disparity.

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—U.S. exports of abrasive materials, by kinds

(Thousands)

Kind	1967		1968	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of precious or semiprecious stones, including diamond dust and powder .... carats..	4,317	$12,526	6,015	$16,616
Crushing bort .... do....	18	210	26	168
Industrial diamond .... do....	148	924	300	1,153
Emery, natural corundum, and other natural abrasives, n.e.c .... pounds..	28,000	1,935	40,431	2,569
MANUFACTURED ABRASIVES				
Artificial corundum (fused aluminum oxide) .... do....	39,128	5,633	31,046	6,311
Silicon carbide, crude or in grains .... do....	12,924	2,680	14,166	2,706
Carbide abrasives, n.e.c .... do....	1,930	1,881	4,933	2,802
Grinding and polishing wheels and stones:				
Diamonds .... carats..	429	2,946	594	3,010
Pulpstones .... pounds..	4,116	1,215	2,199	682
Hand polishing stones, whetstones, oilstones, hones, and similar stones .... pounds..	918	928	737	850
Wheels and stones, n.e.c .... do....	3,628	6,833	5,181	7,404
Abrasive paper and cloth, coated with natural or artificial abrasive materials .... reams..	321	9,290	301	8,973
Coated abrasives, n.e.c	NA	138	NA	1,719
Metallic abrasives .... pounds..	44,118	4,257	53,402	5,303
Total	XX	50,896	XX	60,266

NA Not available. XX Not applicable.

Table 3.—U.S. reexports of abrasive materials, by kinds

(Thousands)

Kind	1967		1968	
	Quantity	Value	Quantity	Value
NATURAL ABRASIVES				
Dust and powder of precious or semiprecious stones, including diamond dust and powder .... carats..	238	$807	198	$497
Crushing bort .... do....	192	1,355	316	2,008
Diamond suitable only for industrial use .... do....	2,271	15,016	3,018	17,242
Emery, natural corundum, and other natural abrasives, n.e.c. pounds..	22	4	24	5
MANUFACTURED ABRASIVES				
Carbide abrasives, n.e.c .... do....	7	7	NA	NA
Grinding and polishing wheels and stones:				
Diamond .... carats..	(1)	6	1	9
Wheels and stones, n.e.c .... pounds..	2	12	2	3
Pulpstones .... do....	1	2	--------	--------
Hand polishing stones, whetstones, oilstones, hones, and similar stones .... pounds..	2	3	2	1
Abrasive paper and cloth,coated with natural or artifical abrasive materials .... reams..	(1)	6	(1)	7
Coated abrasives, n.e.c	NA	8	NA	31
Metallic abrasives .... pounds..	18	13	5	4
Total	XX	17,239	XX	19,807

NA Not available. XX Not applicable.

(1) Less than ½ unit.

Table 4.—U.S. imports for consumption of abrasive materials (natural and artificial), by kinds

(Thousands)

Kind	1967		1968	
	Quantity	Value	Quantity	Value
Corundum, crude or crushed short tons	2	$59	6	$118
Emery, flint, rottenstone, and tripoli, crude and crushed short tons	16	468	32	707
Silicon carbide, crude do	89	10,925	106	14,249
Aluminum oxide, crude do	151	16,446	149	17,085
Other crude artificial abrasives do	6	566	4	322
Abrasives, ground, grains, pulverized, or refined:				
Silicon carbide short tons	3	444	2	717
Aluminum oxide do	7	1,552	8	1,966
Emery, corundum, flint, garnet, and other, including artificial abrasives short tons	([1])	174	1	133
Papers, cloths, and other materials wholly or partly coated with natural or artificial abrasives	([2])	4,292	([2])	5,764
Hones, whetstones, oilstones, and polishing stones number	324	79	376	73
Abrasive wheels and millstones:				
Burrstones, manufactured or bound up into millstones short tons	---------	---------	([1])	4
Solid natural stone wheels number	4	13	1	9
Diamond do	67	242	58	308
Other	([2])	752	([2])	789
Articles not especially provided for:				
Emery or garnet	([2])	7	([2])	26
Natural corundum or artificial abrasive materials	([2])	211	([2])	176
Other	([2])	65	([2])	47
Grit, shot, and sand of iron and steel short tons	2	332	1	121
Diamonds:				
Diamond dies number	10	229	9	239
Crushing bort carats	4,255	10,065	686	1,587
Other industrial diamond do	6,043	35,657	4,260	36,847
Miners' diamond do	781	4,213	912	4,940
Dust and powder do	[r] 6,083	[r] 13,641	7,818	16,953
Total	XX	[r] 100,427	XX	108,125

[r] Revised. XX Not applicable.

[1] Less than ½ unit.

[2] Quantity not reported.

TRIPOLI

Tripoli from Arkansas and Oklahoma, amorphous or soft silica from Illinois, and rottenstone from Pennsylvania are all fine-grained, porous silica materials of such essentially similar compositions and uses that it is convenient to discuss them, without distinction, as a group. The quantity of processed tripoli used in 1968 for abrasive purposes was 18 percent more than in 1967, while filler and other nonabrasive uses increased 19 percent, calling for a 21-percent increase in the output of crude material. Substantially increased quantities were supplied by each of the four producing States, notably Oklahoma, with nearly 22 percent more, and Arkansas, where the output was more than twice that of 1967. The material from these two States was, as usual, sold primarily for abrasive purposes, but an important share of the materials from Illinois and Pennsylvania found use as filler and in miscellaneous minor applications.

Tripoli producers in 1968 were Malvern Minerals Co. in Garland County and Industrial Minerals, Inc. in Polk County, Ark.; Illinois Minerals Co. and Tamms Industries Co., both in Alexander County, Ill.; The Carborundum Co. from operations in Newton County, Mo., and Ottawa County, Okla.; Keystone Filler & Manufacturing Co. and Penn Paint & Filler Co., both in Lycoming County, Pa.

Prices quoted in Engineering and Mining Journal for December 1968, for tripoli and amorphous silica were as follows:

Tripoli, paper bags, 30-ton carload lots, f.o.b. Missouri, cents per pound:	
Once ground through 40 mesh, rose or cream	2¾
Double ground through 40 mesh, rose or cream	2¾
Air floated through 200 mesh	8
Amorphous silica, bags, f.o.b. mine or mill, dollars per ton:	
90–95 percent through 325 mesh	27
96–98 percent through 325 mesh	27
99.5 percent through 325 mesh	39
99.9 percent minus 400 mesh	59
99 percent minus 15 microns	65
99 percent minus 10 microns	85

Table 5.—Processed tripoli[1] sold or used by producers in the United States, by uses[2]

Kind		1964	1965	1966	1967	1968
Abrasives	short tons	42,371	48,935	45,785	44,961	52,837
Value	thousands	$1,831	$2,025	$1,880	$1,916	$2,201
Filler	short tons	10,865	11,011	10,581	11,240	13,418
Value	thousands	$295	$296	$285	$354	$388
Other	short tons	5,253	4,830	4,491	4,797	5,203
Value	thousands	$169	$142	$133	$143	$149
Total[3]	short tons	58,489	64,776	60,857	60,998	71,458
Value	thousands	$2,295	$2,463	$2,298	$2,413	[2] $2,787

[1] Includes amorphous silica and Pennsylvania rottenstone.
[2] Partly estimated.
[3] Data may not add to total shown because of independent rounding.

SPECIAL SILICA STONE PRODUCTS

Special silica-stone products produced in 1968 included oilstones from Arkansas, whetstones from Indiana, grinding pebbles from Minnesota and Wisconsin, grindstones from Ohio, and tube-mill liners from Minnesota. No production of millstones from North Carolina has been reported since 1963. The total tonnage and value of these products sold or used by producers was greater than in 1967, with the increase chiefly attributable to substantially larger output of grinding pebbles in Minnesota and Wisconsin.

Novaculite for oilstones was produced in 1968 by Arkansas Oilstones Co., Inc., John O. Glassford, Cleve Milroy, Norton Pike Division of Norton Co., and Hiram A. Smith Whetstone Co., all from operations in Garland County, Ark.; whetstones by Hindostan Whetstone Co., Orange County, Ind.; grinding pebbles and tube-mill liners by The Jasper Stone Co., Rock County, Minn.; grinding pebbles by Baraboo Quartzite Co., Inc., Sauk County, Wis.; and grindstones by Cleveland Quarries Co., Lorain County, Ohio.

Table 6.—Special silica-stone products sold or used by producers in the United States[1]

Year	Short tons	Value (thousands)
1964	3,186	$292
1965	3,603	482
1966	3,806	515
1967	2,701	574
1968	3,141	629

[1] Includes grinding pebbles, grindstones, oilstones, tube-mill liners and whetstones.

NATURAL SILICATE ABRASIVES

Garnet.—The quantity of domestic garnet sold or used by producers in 1968 more than compensated for the decline noted in 1967. Production increases were reported in both of the producing States, New York and Idaho, each with two active operators. Barton Mines Corp., the largest producer, extracted garnet from an extensive garnetiferous igneous formation in Warren County, N.Y., crushing and sizing the material for use in coated abrasives, for metal lapping, and for grinding and polishing glass. Cabot Corp.'s Oxide Division recovered from treatment of wollastonite ore in Essex County, N.Y., a substantial quantity of byproduct garnet, most of which was used as sandblast abrasive. In Idaho, the Emerald Creek Garnet Milling Co. and the Idaho Garnet Abrasive Co., both working on placer deposits in Benewah County, extracted abrasive-grade garnet for sandblasting and miscellaneous uses.

Table 7.—Abrasive garnet sold or used by producers in the United States

Year	Short tons	Value (thousands)
1964	16,123	$1,622
1965	19,330	1,717
1966	21,952	2,092
1967	20,494	1,849
1968	22,136	1,922

NATURAL ALUMINA ABRASIVES

Corundum.—Abrasive-grade natural corundum, used chiefly for the grinding of optical lenses and in metal lapping, has not been mined in the United States for more than half a century, and for many years the entire quantity used by domestic industry was imported from Southern Rhodesia. Those shipments were halted, however, in mid-1968 because of economic sanctions imposed against that country by the United Nations. Subsequent receipts were made up of mineral from the Republic of South Africa, Canada, and Brazil. The only recipient and processor of imported corundum in the United States, American Abrasive Co. of Westfield, Mass., crushed and classified the material to obtain the commercial product in a number of specified particle-size ranges.

Table 8.—World production of corundum, by countries

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
India	595	530	424	[r] 337	• 330
Rhodesia, Southern	2,870	• 4,600	• 4,600	• 4,600	NA
South Africa, Republic of	60	844	400	[r] 351	NA
U.S.S.R.•	5,500	5,500	5,500	5,500	6,600
Total [1]	9,025	10,974	10,924	10,788	NA

• Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Totals are of listed figures only.

Emery.—Domestic mining of emery in 1968 was confined to Westchester County, N.Y., where reduced output from two producers and the cessation of operations by the third caused the total to be the lowest, in terms of both volume and value that has been reported for a number of years. The two firms now remaining, De Luca Emery Mine, Inc., operating its No. 2 mine near Peekskill, and the Di Rubbo American Emery Ore Company, working the Kingston mine at Croton-on-Hudson, produced material that was processed to serve miscellaneous abrasive purposes and to make skid-guard aggregate for surfacing floors, stair treads, and pavements.

Table 9.—Emery sold or used by producers in the United States

Year	Short tons	Value (thousands)
1964	9,214	$172
1965	10,720	204
1966	11,102	210
1967–68	W	W

W Withheld to avoid disclosing individual company confidential data.

INDUSTRIAL DIAMOND

Imports for consumption of industrial diamond in 1968, although not departing greatly from the pattern established in the preceding 10 years (down less than 1 percent in quantity, up 5 percent in value from that average), took a sharp turn downward—20 percent in volume and 5 percent in value—from the figures of 1967. The most conspicuous drop in industrial diamond imports was that reported in the crushing-bort category, which compared to 1967 imports and, calculated either by value or volume, amounted to a reduction of approximately 85 percent. Although industrial diamond shipments from Ireland were about one-fourth less than in 1967, those from other countries also declined in nearly the same proportion, enabling Ireland to keep its position as foremost supplier of the mineral for import by the United States.

Table 10.—U.S. imports for consumption of industrial diamond (excluding diamond dies)

(Thousand carats and thousand dollars)

Year	Quantity	Value
1966	18,569	$69,110
1967	[r]17,112	[r]63,576
1968	13,676	60,277

Domestic production of synthetic diamond in 1968 was estimated at a record 11 million carats, and approximately 3 million carats was recovered from treatment of swarf and sludges. Thus for the first time in history, the United States was able to supply more than three-quarters of the total industrial diamond requirement from internal sources.

An invitation issued by the General Services Administration in January 1968 for the sealed-bid sale of 59,650 carats of stockpiled industrial diamond stones was rescinded in February pending restudy of the offering. GSA announced in December that Congressional consideration had been solicited for a proposed plan for the orderly disposal from Government inventory of approximately 18 million carats of excess industrial diamond classified as crushing bort.

WORLD REVIEW

Angola.—Exploratory drilling of diamondiferous formations was in progress using a reverse-circulation rotary drilling rig capable of sinking a 62-inch borehole through hard shale and interspersed rock fragments at the rate of up to 30 feet per hour. Cuttings are drawn up by a jet eductor system and ejected into a catch basin for periodic examination. The extraordinary size of the borings is required to yield an accurate determination of the carat-to-waste ratios from the highly varied deposits.

Australia.—Active prospecting was initiated in an effort to determine the source or sources of diamond found sporadically since 1895 in the Carnarvon and Fitzroy Basins, south of Broome and Derby, in northwesternmost Australia.

Botswana.—Discovery was reported of a number of diamond-bearing formations in central Botswana—one at Orapa and others near Lothlikane west of Francistown. At least one of these, with a notably high ratio of industrial material to gem stones, is potentially of major commercial importance.

Canada.—De Beers Consolidated Mines Ltd., world's foremost diamond producers, persuaded by several discoveries of kimberlite east of Kirkland Lake, Ontario, began an intensive search for diamond deposits in that area.

Central African Republic.—Output of the diamond diggings accounted for more than half of the value of the nation's total exports. Exploration for the purpose of further expanding the mining industry was active in search of diamond-bearing beds of gravel in the Lobays river area of sufficient extent to justify large-scale dredging.

China, mainland.—Artificial diamonds with the extreme hardness and other atttributes of the natural mineral are now being manufactured in China, according to information released by the New China News Agency.

Congo (Kinshasa).—Government efforts to curb diamond smuggling are gradually having the desired effect and already have achieved a significant reduction, although not the complete suppression, of the illicit traffic.

Costa Rica.—A new manufacturing firm was organized for the reported purpose of producing synthetic diamond with a total value of over $1 million annually.

Ghana.—It was reported that virtually the entire production from small-scale independent diamond operations was being exported illegally to take advantage of world-market prices, which are substantially higher than those set by the State Diamond Marketing Corporation.

Guyana.—Guyana could become a substantial supplier of industrial diamond within the next few years. Three grades, chiefly bort, have been found throughout a virtually continuous belt some 250 miles long and 100 miles wide. Stones, mostly of industrial quality and with a total value around $1 million have been mined from a single pocket on a claim that, before its eventual depletion, is expected to yield as much as $2.5 million in industrial diamonds.

Table 11.—U.S. imports for consumption of industrial diamond, by countries

(Thousand carats and thousand dollars)

Country	Crushing bort (including all types of bort suitable for crushing)				Other industrial diamond (including glazers' and engravers' diamond, unset)				Miners' diamond				Powder and dust			
	1967		1968		1967		1968		1967		1968		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	83	$228	76	$157	616	$4,039	517	$2,949	3	$13	5	$21	121	$297	109	$241
Brazil	(1)	1	------	------	5	48	3	55	2	18	4	55	(1)	3	------	------
Canada	4	20	8	22	122	829	101	540	36	210	24	86	[r]186	[r]137	450	334
Central African Republic	11	30	10	20	63	1,025	67	1,038	29	46	25	46	------	------	------	------
Congo (Kinshasa)	850	1,923	104	237	832	2,877	81	441	4	23	------	------	22	39	9	20
France	-------	------	(1)	(1)	1	14	4	73	6	64	2	3	------	------	3	4
Germany, West	(1)	1	------	------	35	343	24	217	------	------	1	(1)	29	59	13	25
Ghana	9	24	4	11	373	1,966	429	1,756	------	------	5	12	[r]3	[r]10	14	37
Ireland	2,664	6,239	105	253	534	1,918	11	29	368	2,097	582	3,137	[r]4,731	[r]11,019	5,805	13,038
Israel	-------	------	(1)	4	12	97	26	437	1	38	------	------	6	7	4	9
Japan	(1)	(1)	1	(1)	140	958	96	1,160	------	------	30	66	160	355	363	804
Netherlands	97	216	113	233	201	1,567	323	4,229	12	82	7	145	115	276	108	259
Sierre Leone	-------	------	------	------	43	811	120	2,395	------	------	------	------	------	------	(1)	(1)
South Africa, Republic of	461	1,116	184	419	1,907	10,829	1,422	10,396	235	1,364	182	1,112	81	197	193	584
Switzerland	-------	------	2	5	3	8	8	84	------	------	------	------	73	146	92	196
United Kingdom	5	22	21	49	698	4,966	650	7,108	30	208	15	107	489	942	562	1,144
Venezuela	2	7	1	3	14	127	7	63	------	------	1	3	------	------	------	-------
Western Africa, n.e.c	58	211	57	124	411	2,952	358	3,210	5	44	21	115	16	40	87	251
Other	11	27	------	------	33	283	13	667	(1)	6	8	32	51	114	8	7
Total	4,255	10,065	686	1,587	6,043	35,657	4,260	36,847	731	4,213	912	4,940	[r]6,083	[r]13,641	7,818	16,953

[r] Revised.

(1) Less than ½ unit.

Table 12.—World production of industrial diamond, by countries

(Thousand carats)

Country	1964	1965	1966	1967	1968 [p]
Africa:					
Angola	[r] 275	[r] 268	[r] 300	[r] 306	351
Central African Republic	221	269	270	260	[e] 304
Congo (Kinshasa)	14,457	12,490	[r] 12,418	[r] 12,891	11,358
Congo (Brazzaville) [e] [1] [2]	4,949	4,982	5,000	5,000	NA
Ghana	2,290	2,248	2,537	2,283	[e] 2,202
Guinea [e]	[1] 51	51	51	50	NA
Ivory Coast	80	79	74	[e] 70	[e] 77
Liberia [1]	273	263	212	[r] 181	213
Sierra Leone	878	804	833	[r] 840	[3] 850
South-West Africa [e]	154	[r] 155	176	[r] [3] 170	170
Tanzania (exports)	326	414	473	[r] 123	327
South Africa, Republic of: [e]					
Premier	1,668	1,829	1,975	1,783	1,824
De Beers Group [4]	759	726	1,169	1,742	1,888
Other pipe mines	41	288	306	222	322
Alluvial	192	154	200		
Total South Africa, Republic of	2,660	2,997	3,650	[r] 3,747	4,034
Total Africa	[r] 26,614	[r] 25,020	[r] 25,994	[r] 25,921	19,881
Other areas:					
Brazil [e]	175	175	150	160	NA
Guyana	[r] 49	68	[r] 59	[r] 56	38
India	(5)	1	(5)	[r] 2	1
Indonesia [e]	[r] 21	[r] 21	[r] 21	[r] 21	21
U.S.S.R. [e]	3,200	4,000	4,800	5,600	5,600
Venezuela	58	39	43	[r] 31	54
Total [6]	[r] 30,117	[r] 29,324	[r] 31,067	[r] 31,791	25,595

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Exports, fiscal year ending August 31 of year.

[2] Probable origin, Republic of the Congo (Kinshasa).

[3] Output of Consolidated Diamond Mines of South-West Africa Ltd.

[4] Includes some alluvial diamond from De Beers properties.

[5] Less than ½ unit.

[6] Total is of listed figures only.

India.—The Geological Survey of India initiated an intensive 2- to 3-year survey aimed at a quantitative assessment of the potentialities for diamond production, both industrial and gem grade, from the diamondiferous areas in the State of Andhra Pradesh on the Bay of Bengal, the region that was the source, historically or in legend, of the Koh-i-Noor, the Regent, the Orloff, and the Hope diamonds.

Sierra Leone.—Industrial diamonds continued to be the foremost source of export income. Diamond purchases by the Sierra Leone Government Diamond Office, virtually all for export, totaled nearly $30 million in 1967.

South Africa, Republic of.—The international significance of the Republic's diamond industry was highlighted by the announcement that in 1967 De Beers Consolidated Mines Ltd., without counting the gains from lease to others of certain De Beers-controlled property, realized from diamond operations approximately R90 million, or the equivalent of about $126 million, in actual net profit.

The Buffelsbank diamond mine, about 300 miles north of Capetown in Namaqualand, was placed in full operation early in 1968. It is anticipated that production from this mine will be around 30,000 carats annually for at least the next 6 years.

Tanzania.—Although tonnage of ore treated in the nation's diamond operations was at an alltime high in 1967, carat output diminished by at least 2 percent. An investigation was therefore undertaken to determine the economic feasibility of establishing a tailings retreatment plant at Mwadui to increase the declining yield from the progressively poorer ground being treated.

U.S.S.R.—Exploration was started for the purpose of determining the validity of conclusions drawn by geologists 2 decades ago concerning the likelihood of the occurrence of kimberlite or similar diamond-bearing formations in North Kazakhstan.

Soviet scientists reported, with little descriptive detail, the development of a novel process for producing synthetic diamond in the form of filamentous crystals several millimeters in length. The thread-like diamond particles, 10 to 50 microns in diameter, are said to be grown at the rate of 1½ millimeters per hour in a hydrogen-containing gaseous medium at less than 1 atmosphere pressure and at a temperature not specified but characterized as "low."

TECHNOLOGY

Diamond abrasive shaping has come to play an indispensable role in the fabrication of the sophisticated optical components required for the proper functioning of space-age mechanisms. In this field it is no longer unusual to have tolerances of ten-millionths of an inch specified and routinely delivered. Not only extreme precision but also extraordinary economy of time has become possible with some of the newly designed diamond grinding equipment. In a recent demonstration one of the machines turned out in just 8 minutes a lens 30 inches in diameter that would have required a full month for a skilled craftsman to grind by hand.[2]

A novel application of diamond-studded core bits was successful in resolving a drilling problem for the Australian Atomic Energy Commission. An unconventional driving mechanism, specially designed for the problem satisfactorily overcame the handicaps of limited access and cramped working space, to take advantage of the capabilities of industrial diamond for drilling the required number of close-tolerance holes at precisely specified angles through the steel and high-density concrete door and walls of a nuclear reactor.[3]

Results obtained thus far in an intensive and practical analysis of the technical factors involved in the use of industrial diamond abrasive wheels for finishing ceramic articles of widely divergent properties and compositions were published.[4]

Substantial progress was achieved in the search for economically feasible techniques for diamond-wheel grinding of "soft" metals (steel, for example, is "soft" as compared with tungsten carbide). Use of a new type of metal-clad abrasive diamond and an increase in the griding wheel dimensions both resulted in greatly improved performance. A third advance, not so predictable but of major importance, was realized through experiments involving variations in grinding wheel hub compositions.[5]

Adequate finishing of ruby laser rods, especially on the critically important end surfaces, requires the abrasive action of industrial diamond. A laser manufacturer has found that the purpose can best be served by using diamond dust that is precisely graded by a newly devised process into fractional-micron size ranges and applied directly from disposable polyethylene syringes to guard against damage by intrusive oversize particles.[6]

Innovative uses of industrial diamond were described, in which powerful gang-saws, each mounting 25 diamond-impregnated blades over 12 feet in length, efficiently reduce massive blocks of structural marble of half-inch slices.[7]

Scientists in the Republic of South Africa devised a mechanism that, by taking advantage of the fluorescence that X-rays induce in all types of diamonds, expeditiously separates the valuable crystals from the accompanying gravel. Diamond-bearing concentrate from the ore washing plant passes between an X-ray source and a photocell sensitive only to the blue light produced by irradiated diamonds. Thus the presence of diamonds in the ore stream causes the cell to generate impulses that trigger puffs of air to divert the fluorescing particles into a separate path. Preliminary trials showed that well over 99 percent of the diamond content of the entering material was recovered by this new sorting apparatus.[8]

---

[2] Marsden, Paul. Diamond and the Optical Revolution. Industrial Diamond Rev., v. 28, No. 329, April 1968, pp. 154–156.

[3] Industrial Diamond Review. Drilling Through High Density Concrete. V. 27, No. 325, December 1967, pp. 522–523.

[4] Gielisse, P. J., W. F. Mathewson, J. A. Martis, and E. Ratterman. Ceramic Finishing With Diamond. Ceram. Ind. Mag., v. 90, No. 2, February 1968, pp. 38–41 (Part I: The Workpiece); No. 3, March 1968, pp. 32–35, 49 (Part II: Abrasive and Bond System); and No. 4, April 1968, pp. 124–127 (Part III: External Influences and Cost Analysis).

[5] Dyer, Dr. Henry B. Grinding Steel With Diamonds. Industrial Diamond Rev., v. 28, No. 326, January 1968, pp. 6–13.

———. Grind Steel With Diamonds. Grinding and Finishing, v. 14, No. 3, March 1968, pp. 38–41.

[6] Grinding and Finishing. Clean Diamond Polishes Ruby Laser Rods. V. 14, No. 3, March 1968, p. 33.

[7] Industrial Diamond Review. An American Firm Slices, Shapes and Surfaces Marble With Diamond. V. 27, No. 325, December 1967, pp. 514–515.

Quick and reliable determination of the hardness of large or small samples of synthetic diamond was claimed for a testing method based on the use of ultrasonic vibration that was devised by scientists in the U.S.S.R.[9]

A journal article reported results of a study which compared the performance of several natural diamond lapping powders in working a selection of tungsten carbides, steels, and ceramics, with that of a newly available synthetic diamond material. It was concluded that, among the powders investigated for these applications, careful sizing and certain inherent characteristics made the synthetic powder equal or superior to those that were of natural origin.[10]

Although research in synthetic diamond production technology continued to be active throughout the year and while numerous patents, predominantly foreign, were issued pertaining to the subject, no major and conspicuous innovations were reported in 1968.

ARTIFICIAL ABRASIVES

Crude fused aluminum oxide abrasive material was produced in the United States and Canada in 1968 by the same six firms as in 1967. Pyrominerals Limited, of Sydney, Nova Scotia, announced in 1968 a more than twofold expansion of its plant capacity, from 18,000 tons to 45,000 tons per year. The combined U.S. and Canadian outputs, consisting of regular-grade material and white, high-purity material in a ratio of about 8 to 1 by weight, 6 to 1 by value, represented 54 percent of total rated plant capacity. It was estimated that 13 percent of the fused aluminum oxide from plants in the United States and Canada was sold for nonabrasive purposes, mainly for the manufacture of refractories.

Silicon carbide was produced in 1968 in the United States and Canada by six firms, all but one of which furnished material for both abrasive and nonabrasive uses. The entire production of the sixth firm, the Satellite Alloy Corp., operating in Allegheny County, Pa., was consumed in nonabrasive applications. A major producer, the Norton Co., increased by 10 percent the production capacity of its Canadian operations. The overall 1968 silicon carbide output, which amounted to 89 percent of the industry's total rated plant capacity, was sold for abrasive and nonabrasive uses in virtually equal proportions. The quantity not employed as an abrasive was variously consumed as a refractory material, as a deoxidizer for ferrous metals, in electrical applications, and as a source of elemental silicon.

Essentially all the abrasive-grade aluminum oxide and silicon carbide produced in Canada was shipped to the United States for processing into specified grain-size fractions, in which form part was subsequently returned to Canada for fabrication into grinding wheels and other abrasive products.

The 1968 production of metallic abrasives in the United States exceeded the previous record output by 6 percent in quantity and 7 percent in total value. Ohio had an output equivalent to 37 percent of the national total and almost twice that of the nearest competitor. Three States taken together—Michigan, Indiana, and Pennsylvania—furnished 53 percent of the total, and the remaining 10 percent was made up of the contributions of four other States. Minnesota, formerly a producer, had no recorded output in 1968.

TECHNOLOGY

In cutting slabs of stainless steel up to 6 inches thick and 18 feet long, a New England manufacturer realized important economics both of material and of labor time by replacing earlier methods by a special adaptation of rubber-bonded aluminum oxide cutting wheels—30 inches in diameter, loaded at 190 pounds, and turning at 1,100 revolutions per minute (rpm), as compared with the 26 inches, 167 pounds, and 1,450 rpm suitable for lighter

---

[8] South African Mining and Engineering Journal. Diamond Recovery by X-Ray. V. 79, No. 3930, May 31, 1968, pp. 1388–1390.

[9] Pluzhnik, V. I., and G. F. Skripko. Rapid Hardness Testing of Synthetic Diamonds. Industrial Diamond Rev., v. 28, No. 328, March 1968, p. 126.

[10] West, Warren. There's a Difference in Diamond Lapping Powders. Grinding and Finishing, v. 14, No. 5, May 1968, pp. 30–31.

Table 13.—Crude artificial abrasives produced in the United States and Canada

(Thousand short tons and thousand dollars)

Kind	1964	1965	1966	1967	1968
Silicon carbide [1] quantity	132	138	159	142	159
Value	$18,432	$19,963	$21,674	$19,612	$23,833
Aluminum oxide (abrasive grade)[1] quantity	171	195	244	207	192
Value	21,493	24,909	29,981	28,183	27,705
Metallic abrasives [2] quantity	156	191	205	204	216
Value	23,445	28,230	31,139	32,610	34,778
Total [3] quantity	459	524	608	553	[3] 568
Value	63,370	73,102	82,794	80,405	86,316

[1] Figures include material used for refractories and other nonabrasive purposes.
[2] Shipments for U.S. plants only.
[3] Data may not add to total shown because of independent rounding.

Table 14.—Production, shipments, and stocks of metallic abrasives in the United States, by products

Year and product	Manufactured		Sold or used		Stocks Dec. 31 (short tons)	Annual capacity (short tons)
	Short tons	Value (thousands)	Short tons	Value (thousands)		
1967:						
Chilled iron shot and grit	41,585	$4,099	41,014	$4,662	5,630	245,605
Annealed iron shot and grit	44,115	4,870	43,704	5,622	1,493	[1] 72,299
Steel shot and grit	119,065	17,055	116,302	21,736	8,398	143,142
Other [2]	2,801	466	3,312	590	123	11,400
Total	207,566	26,490	204,332	32,610	[3] 15,639	400,147
1968:						
Chilled iron shot and grit	38,500	3,714	37,776	4,192	6,354	247,015
Annealed iron shot and grit	45,970	4,927	46,070	5,978	1,398	[1] 171,487
Steel shot and grit	130,698	18,363	130,668	24,203	8,423	148,163
Other [2]	1,728	348	1,688	405	163	11,250
Total	216,896	27,352	216,202	34,778	16,333	406,428

[1] Included in capacity of chilled iron shot and grit.
[2] Includes cut wire shot.
[3] Includes revisions in product detail.

Table 15.—Stocks of crude artificial abrasives and capacity of manufacturing plants, as reported by producers in the United States and Canada

(Thousand short tons)

Year	Silicon carbide		Aluminum oxide		Metallic abrasives [1]	
	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity	Stocks Dec. 31	Annual capacity
1964	15.0	152.5	14.5	298.8	23.1	386.0
1965	9.1	155.9	10.9	304.8	17.9	376.8
1966	17.5	174.4	18.6	310.8	12.7	373.5
1967	12.9	176.1	30.2	330.2	[r] 15.6	400.1
1968	17.7	179.7	25.5	357.2	16.3	406.4

[r] Revised.
[1] United States only.

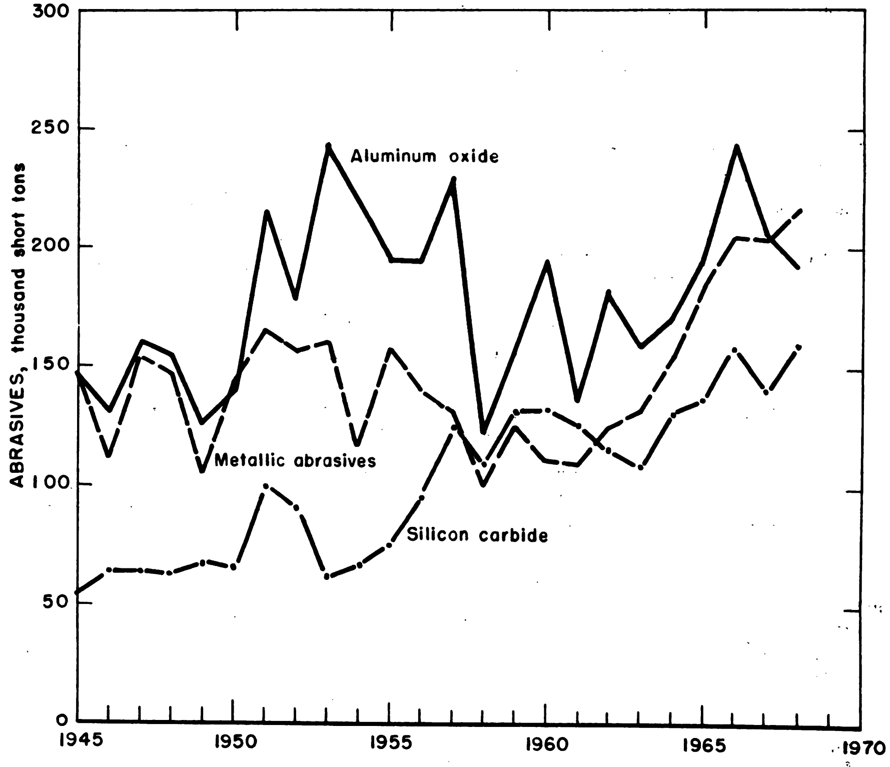

Figure 1.—Artificial abrasive production.

plates. The new process leaves the cut surfaces in a semifinished condition.[11]

A new machine uses modern manufactured abrasives rather than a sharpened blade to cut away surplus wood faster and at less cost than by conventional planing methods, while holding the surfaces to tolerances expressed in ten-thousandths of an inch.[12]

---

[11] Iron Age, Abrasives Bite Into Thick Plates. V. 202, No. 3, July 18, 1968, pp. 74–75.

[12] Loehwing, David A. Scratching the Surface. Barron's, June 24, 1968, pp. 3, 33–24, 26–27.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/200

Aluminum

By John G. Parker [1]

Although domestic primary production decreased slightly because of a midyear strike, total world production increased but not at the rate of the previous year. By 1972, in anticipation of industrial expansion throughout the free world, there was expected to be nearly a 50-percent increase in primary production capacity. Reflecting added expenses to the industry, aluminum prices were increased at midyear.

Legislation and Government Programs.—During the year sales of primary aluminum under the disposal program initiated in November 1965 totaled 56,554 tons, of which 56,075 tons went to four of the seven participating primary producers and the small remainder to three nonparticipating firms.

Throughout 1968, Business and Defense Services Administration, U.S. Department of Commerce, established the aluminum set-aside for defense and related orders at 150,000 tons per quarter, the same as in the previous year.

Table 1.—Salient aluminum statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Primary production	2,553	2,754	2,968	3,269	3,255
Value	$1,196,013	$1,337,795	$1,446,011	$1,614,483	$1,639,621
Price: Ingot, average cents per pound	23.7	24.5	24.5	25.0	25.6
Secondary recovery	552	641	693	698	817
Exports (crude and semicrude)	349	315	330	366	351
Imports for consumption (crude and semicrude)	453	620	679	539	785
Consumption, apparent	3,216	3,734	4,002	4,009	4,656
World: Production	6,553	6,951	7,583	8,352	8,864

DOMESTIC PRODUCTION

Primary.—Domestic primary aluminum output in the 13 States with aluminum reduction plants decreased slightly from that in the 1967 record year, largely due to a midyear strike at two principal producers. Five plants in four States were hit by the strike. As usual, Washington State led in total production with 775,419 tons valued at $394.3 million.

Production capacities were increased by Aluminum Company of America (Alcoa) at Rockdale, Tex.; Reynolds Metals Company at Longview, Wash.; Kaiser Aluminum & Chemical Corp. at Tacoma, Wash.; Anaconda Aluminum Co. at Columbia Falls, Mont.; Consolidated Aluminum Corp. at New Johnsonville, Tenn.; Harvey Aluminum, Inc. at The Dalles, Oreg.; and Intalco Aluminum Corp. at Bellingham, Wash. Expansions of primary capacity at plants now in operation and plans for new facilities by companies not now producing primary ingot in the United States were given in a comprehensive article.[2]

Table 2.—Production and shipments of primary aluminum in the United States

(Short tons)

Quarter	1967		1968	
	Production	Shipments	Production	Shipments
First	783,189	788,213	840,723	898,459
Second	817,445	777,440	787,864	839,731
Third	824,919	747,155	741,431	756,857
Fourth	843,706	823,328	885,024	908,008
Total	3,269,259	3,136,136	3,255,042	3,403,055

---

[1] Physical scientist, Division of Mineral Studies.

[2] Metals Week. Aluminum-Profile of an Industry: The Primary Producers. V. 39, No. 29, July 15, 1968, pp. 4A–30A.

Table 3.—Aluminum recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1967	1968
New scrap:		
Aluminum-base	[1] 568,782	[2] 661,570
Copper-base	81	105
Zinc-base	71	88
Magnesium-base	313	434
Total	569,247	662,197
Old scrap:		
Aluminum-base	[1] 127,681	[2] 153,959
Copper-base	70	77
Zinc-base	569	544
Magnesium-base	184	131
Total	128,504	154,711
Grand total	697,751	816,908

Form of recovery	1967	1968
As metal	53,656	72,132
Aluminum alloys	628,848	728,784
In brass and bronze	643	762
In zinc-base alloys	8,304	7,067
In magnesium alloys	1,195	1,039
In chemical compounds	5,105	7,124
Total	697,751	816,908

[1] Aluminum alloys recovered from aluminum-base scrap in 1967, including all constituents, were 602,064 tons from new scrap and 145,392 tons from old scrap and sweated pig, a total of 747,456 tons.

[2] Aluminum alloys recovered from aluminum-base scrap in 1968, including all constituents, were 699,147 tons from new scrap and 175,415 tons from old scrap and sweated pig, a total of 874,562 tons.

Alcan Aluminium Limited, the Canadian-based firm, hoped to strengthen its share of the U.S. market as it moved toward the purchase of Metal Goods Corp., a St. Louis-based metals distributor which has distributed for such firms as Alcoa and The Anaconda Company. Alcoa planned to install a 220-inch-wide hot rolling mill, the world's largest, at Davenport, Iowa, by early 1971.[3] A large rolling mill in Grundy County, near Joliet, Ill., owned by Amax Aluminum Co., went on stream.[4] By late 1969 it will have attained its full capacity of 45,000 tons per year, thus doubling the company's sheet production capacity. A primary reduction facility being built near Frederick, Md., by Eastalco Aluminum Co., a joint enterprise of Howmet Corp. and Pechiney Enterprises Inc., will be in operation in 1970. Eventually the $190 million plant will have three potlines, each rated at 85,000 tons per year. Harvey Aluminum, 41 percent of which was bought by Martin Marietta Corporation late in 1968, planned to erect a 100,000-ton, two-potline reduction facility 25 miles southwest of Goldendale, Wash., near the John Day Dam.[5] A local supply of calcined coke for anodes used in Kaiser Aluminum's Chalmette, La., aluminum reduction plant became available when a $2 million coke calcining plant went into operation at the site. Near year-end National-Southwire Aluminum Co., jointly owned by Southwire Co. and National Steel Corp., announced that a fourth potline will be added to the primary aluminum reduction plant now being built at Hawesville, Ky., thus bringing total capacity to 180,000 tons per year. Revere Copper and Brass began construction of a 110,000-ton primary aluminum reduction plant at Goose Pond Island near Scottsboro, Ala., the first potline of which is scheduled for completion in 1971.[6] In the same complex is a new $60 million, 90,000-ton aluminum rolling mill which will eventually be supplied with hot metal by the reduction plant.

Secondary.—Recovery of secondary alumium was 817,000 tons, 17 percent greater than that in 1967. Domestic recovery of aluminum alloys (including all constituents) from aluminum-base scrap was 875,000 tons. Metallic recovery from new scrap was 699,000 tons, an increase of 16 percent; metallic recovery from old scrap and sweated pig rose 20 percent to over 175,000 tons. Also, 1,379 tons was recovered from copper-, zinc-, and magnesium-base scrap. The value of 815,529 tons of aluminum recovered from processed aluminum scrap was $417 million computed from the average price of primary aluminum ingot of 25.58 cents per pound.

The calculated consumption of purchased aluminum-base scrap and sweated pig,

---

[3] Aluminum Company of America. 1968 Annual Report. Feb. 20, 1969, 32 pp.

[4] American Metal Climax, Inc. (AMAX). Annual Report 1968, 38 pp.

[5] Harvey Aluminum, Inc. Annual Report for the Fiscal Year ended Sept. 30, 1968, 40 pp.

[6] Revere Copper and Brass Inc. Annual Report. 1968, 28 pp.

Table 4.—Stocks, receipts, and consumption of new and old aluminum scrap and sweated pig in the United States in 1968[1]

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption [2]	Stocks Dec. 31
Secondary smelters:[3]				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	5,049	104,705	105,339	4,415
Segregated high copper	1,672	23,959	24,796	835
Mixed low copper (Cu maximum, 0.4 percent)	1,975	60,766	60,686	2,055
High zinc (7000 series type)	532	7,621	7,731	422
Mixed clips	W	W	W	W
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	W	W	W	W
Zinc, under 0.5 percent	W	W	W	W
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	1,565	57,346	57,697	1,214
Foil, dross, skimmings, and other	12,661	98,853	99,208	12,306
Total new scrap	28,855	529,809	531,268	27,396
Old scrap (solids)	6,067	114,585	113,907	6,745
Sweated pig (purchased for own use)	5,229	51,638	54,114	2,753
Total all classes	40,151	696,032	699,289	36,894
Primary producers, foundries, fabricators, and chemical plants:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	2,706	136,227	135,976	2,957
Segregated high copper	135	13,605	13,575	165
Mixed low copper (Cu maximum, 0.4 percent)	3,136	53,665	51,770	5,031
High zinc (7000 series type)	275	2,465	2,468	277
Mixed clips	W	W	W	W
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	W	W	W	W
Zinc, under 0.5 percent	W	W	W	W
Zinc, 0.5 to 1.0 percent	W	W	W	W
Other	264	24,007	24,102	169
Foil, dross, skimmings, and other	1,269	40,155	39,041	2,388
Total new scrap	8,043	280,818	277,454	11,407
Old scrap (solids)	300	8,500	8,471	329
Sweated pig (purchased for own use)	3,413	30,138	29,856	3,695
Total all classes	11,756	319,456	315,781	15,431
Total of all scrap consumed:				
New scrap:				
Solids:				
Segregated low copper (Cu maximum, 0.4 percent)	7,755	240,932	241,315	7,372
Segregated high copper	1,807	37,564	38,371	1,000
Mixed low copper (Cu maximum, 0.4 percent)	5,111	114,431	112,456	7,086
High zinc (7000 series type)	807	10,086	10,194	699
Mixed clips	2,406	78,070	77,918	2,558
Borings and turnings:				
Low copper (Cu maximum, 0.4 percent)	698	24,502	23,831	1,369
Zinc, under 0.5 percent	349	21,996	21,561	784
Zinc, 0.5 to 1.0 percent	2,206	62,685	63,028	1,863
Other	1,829	81,353	81,799	1,383
Foil, dross, skimmings, and other	13,930	139,008	138,249	14,689
Total new scrap	36,898	810,627	808,722	38,803
Old scrap (solids)	6,367	123,085	122,378	7,074
Sweated pig (purchased for own use)	8,642	81,776	83,970	6,448
Total all classes	51,907	1,015,488	1,015,070	52,325

[r] Revised. W Withheld to avoid disclosing individual company confidential data.
[1] Includes imported scrap.
[2] Calculated.
[3] Excludes secondary smelters owned by primary aluminum companies.

based on reports of consumers, totaled 1.015 million tons with independent secondary smelters using 69 percent of this total. Primary producers used 152,176 tons or 15 percent; fabricators, 75,625 tons or 7 percent; foundries, 80,856 tons and chemical plants, 7,124 tons.

Table 5.—Production and shipments of secondary aluminum alloys, by independent smelters

(Short tons)[1]

	1967		1968	
	Production [2]	Shipments [2]	Production [2]	Shipments [2]
Pure aluminum (Al minimum, 97.0 percent)	53,656	53,509	72,132	72,335
Aluminum-silicon:				
95/5 Al-Si, 356, etc. (maximum Cu 0.6 percent)	20,310	20,256	19,804	19,924
13 percent Si, 360, etc. (maximum Cu, 0.6 percent)	42,679	42,224	42,668	42,684
Aluminum-silicon (Cu, 0.6 to 2 percent)	8,494	8,372	8,160	8,305
No. 12 and variations	7,504	7,448	6,997	7,150
Aluminum-copper (maximum Si, 1.5 percent)	643	683	762	775
No. 319 and variations	50,914	51,326	49,672	49,903
Nos. 122, 138	956	991	726	721
AXS–679 and variations	285,535	287,316	338,495	333,846
Aluminum-silicon-copper-nickel	24,675	24,791	28,234	27,973
Deoxidizing and other destructive uses:				
Grades 1 and 2	14,323	14,391	16,932	16,596
Grades 3 and 4	13,118	13,964	10,186	10,457
Aluminum-base hardeners	6,818	6,722	7,001	7,026
Aluminum-magnesium	1,195	1,297	1,039	1,142
Aluminum-zinc	8,304	8,398	7,067	7,312
Miscellaneous	32,454	32,489	25,317	25,597
Total	571,578	574,177	635,192	681,696

[1] Gross weight, including copper, silicon, and other alloying elements. Secondary smelters used 21,134 and 25,021 tons of primary aluminum in 1967 and 1968, respectively, in producing secondary aluminum-base alloys.

[2] No allowance was made for consumption or receipts by producing plants.

The Bureau of Mines estimated that complete coverage of the industry would show a total scrap consumption of 1.188 million tons and a secondary ingot production of 743,000 tons. Calculated aluminum recovery based on full coverage would total 925,000 tons and the metallic aluminum alloy recovery would total 997,000 tons. Secondary aluminum alloy-ingot production totaled 635,200 tons, 11 percent more than that in 1967. Excluded from data on remelt ingot were alloys produced from purchased scrap by primary producers. Contributing to the larger production of secondary aluminum were increases in output of pure aluminum, and in the alloy AXS–679 and variations.

Data obtained through a Bureau of Mines canvass were combined with data made available to the Bureau by The Aluminum Smelters Research Institute. These data covered operations of the Institute's members which represent more than 75 percent of the secondary aluminum smelter industry.

In January, Vulcan Materials Co., Birmingham, Ala., acquired Aluminum & Magnesium Inc., Sandusky, Ohio, and renamed it the A & M Division. The new secondary smelter at Oak Creek, Wis., ready in 1969, will give the division a total capacity of more than 130,000 tons per year.

By early 1969, near its Listerhill, Ala., aluminum reduction plant, Reynolds Metals Co. planned to complete a reclamation plant which will recycle aluminum by converting scrap into ingot. The unit's three gas-fired melting furnaces will have an annual capacity of 30,000 tons.

CONSUMPTION

Apparent consumption of aluminum in 1968 was 16 percent more than that in 1967, due principally to increases in primary metal sold or used by producers and in net imports of crude and semicrude metal.

Net shipments of aluminum wrought and cast products by producers in 1968 rose by 11 percent. Accounting for most of the increase were larger shipments of sheet, plate, and foil while the only decrease was in shipments of sand castings.

According to figures compiled by the Aluminum Association from industry estimates, the distribution of shipments of aluminum metal to various industries was as follows:

Industry	Percent of total 1967	Percent of total 1968
Building and construction	r 21.6	22.5
Transportation	r 19.9	19.7
Electrical	r 14.0	13.2
Containers and packaging	r 9.7	10.2
Consumer durables	r 9.3	9.9
Machinery and equipment	r 6.9	6.9
Exports	7.3	6.4
Other	r 11.3	11.2
Total	100.0	100.0

r Revised.

In the largest category, building and construction, despite increasing competition from vinyl home siding, shipments of alumium residential siding increased over 13 percent. Adding to the increased share of the market held by this sector was the transfer of mobile home manufacture from the transportation category.

Also contributing to decline in shipments for transportation were cost-cutting and stretchouts in aerospace programs; on the other hand, usage in automobiles was estimated to have increased. Aluminum was also used in government and commercial marine vessels including new-type Navy landing craft and in an all-aluminum patrol gunboat.

Table 6.—Apparent consumption of aluminum in the United States

(Short tons)

Year	Primary sold or used by producers	Imports (net)[1]	Recovery from old scrap[2]	Recovery from new scrap[2]	Total apparent consumption
1964	2,554,898	109,901	123,677	428,014	3,216,490
1965	2,786,584	306,819	159,704	481,014	3,734,121
1966	2,958,274	350,400	136,876	556,155	4,001,705
1967	3,136,136	174,723	128,504	569,247	4,008,610
1968	3,403,055	435,713	154,711	662,197	4,655,676

[1] Crude and semicrude. Includes ingot equivalent of scrap imports and exports (weight multiplied by 0.9).
[2] Aluminum content.

Table 7.—Net shipments[1] of aluminum wrought and cast products[2] by producers

(Short tons)

	1967	1968 p
Wrought products:		
Sheet, plate, and foil	r 1,658,737	1,956,676
Rolled and continuous cast rod and bar; wire	r 460,854	483,723
Extruded rod, bar, pipe, shapes, drawn and welded tubing and rolled structural shapes	r 856,075	935,661
Powder, flake, paste	r 117,002	138,186
Forgings	r 82,610	86,285
Total	r 3,175,278	3,600,531
Castings:		
Sand	125,310	110,210
Permanent mold	191,284	219,898
Die	438,474	441,613
Others	12,288	12,424
Total	767,356	784,145
Grand total	r 3,942,634	4,384,676

p Preliminary. r Revised.

[1] Derived by subtracting the sum of producer's domestic receipts of each mill shape from the domestic industry's gross shipments of that shape.

[2] Figures derived from a new probability sample.

Table 8.—Distribution of wrought products

(Percent)

	1967 r	1968 p
Sheet, plate, and foil:		
Non-heat-treatable	39.4	41.8
Heat-treatable	5.7	5.4
Foil	7.1	7.1
Rolled and continuous cast rod and bar; wire:		
Rod, bar, etc	2.3	2.2
Bare wire, conductor and non-conductor	1.5	1.4
Bare cable (including steel-reinforced)	8.0	6.9
Wire and cable, insulated or covered	2.8	3.0
Extruded rod, bar, pipe, tube, and shapes:		
Alloys other than 2000 and 7000 series	[1] 22.4	21.8
Alloys in 2000 and 7000 series	1.8	1.4
Tubing:		
Drawn	1.4	1.3
Welded, non-heat-treatable[2]	1.4	1.5
Powder, flake, and paste:		
Atomized	3.2	3.4
Flaked	(3)	(3)
Paste	.3	.3
Powder, n.e.c	.1	.1
Forgings (including impact extrusions)	2.6	2.4
Total	100.0	100.0

r Revised. p Preliminary.

[1] Includes a small amount of rolled structural shapes.

[2] Includes a small amount of heat-treatable welded tubing.

[3] Less than .1 percent.

In electrical applications, (1) aluminum-coated steel-reinforced (ACSR) and bare cable and (2) insulated or covered wire and cable again formed over 50 percent of shipments. Fluctuating prices of copper and uncertainty of supply led to increases in the use of aluminum wire in telephone cables. The Baltimore, Md., cable plant of Western Electric Company planned to have a capacity of 500 million conductor feet per year of plastic-insulated aluminum telephone cable by early 1969 and to be able to supply 5 billion conductor feet per year to the Bell System network by April 1970.

The largest percentage increases were in containers and packaging, mostly as metal and composite cans and as foil, and in consumer durables, where usage in refrigerators and in air conditioning, which forms a large part of this category, was followed in quantity by cooking utensils. Another growing part of consumer durables was pleasure boats and outboard motors. The subcategory of military landing mats was shifted from the building category to "Other," which is composed mostly of defense items.

The markets are discussed in detail in one part of a comprehensive series of articles on aluminum published in 1968.[7]

STOCKS

On December 31, 1968, stocks of aluminum ingot in the hands of primary producers were 70,914 tons, compared with 218,927 tons on December 31, 1967. A new reporting method used by a major producer caused the apparent large drawdown in stocks. In addition to the reported primary stocks, reduction plants also maintained inventories of ingot and aluminum in process.

Inventories of secondary aluminum alloy ingot increased 14 percent to 28,700 tons, equivalent to slightly over two weeks supply based on shipments for the year. Consumers' yearend inventories of purchased aluminum scrap increased less than 1 percent and were equivalent to less than 3 weeks supply based on the total quantity melted or consumed during the year.

PRICES

Added expenses, including those incurred in contract agreements signed with striking unions, were claimed to be responsible for increases in aluminum prices. The published domestic price for unalloyed primary aluminum ingot, of 99.5 percent purity, was increased to 26 cents per pound in June. At the same time, prices on major producer alloys and most semifabricated products were increased about 4 percent, and the quoted price for super pure aluminum (99.99 percent aluminum) was raised 1 cent to 41.5 cents per pound.

According to American Metal Market late in 1968, prices of various grades of smelter alloys had risen. For example, 380 (AXS–679) alloy ranged from 25.5 cents per pound with 3 percent zinc content to 26 cents per pound with 1 percent zinc content; steel deoxidizing grades of aluminum alloy ranged from grade 4, 85 percent minimum aluminum at 23.5 cents per pound to grade 1, 95 percent minimum aluminum at 26.75 cents per pound.

FOREIGN TRADE

Exports of crude and semicrude aluminum were 4 percent less than in 1967, whereas the total value decreased nearly 6 percent. The United States shipped 18 percent of all its exports of ingots, slabs, and crude to Belgium-Luxembourg, 11 percent to Japan, and 7 percent to France. Exports of scrap decreased 9 percent, with West Germany and Japan receiving 36 and 27 percent, respectively.

Total net imports of aluminum established a new record of 435,000 tons, due largely to greatly increased imports of crude aluminum metal and alloys. Canada again was our major supplier of these materials with 71 percent of the total.

---

[7] Metals Week. Aluminum-Profile of an Industry: The Major Markets. V. 39, No. 42, Oct. 14, 1968, pp. 104A–137A.

Effective January 1, 1968, in accordance with Kennedy Round trade agreements, duties on certain unwrought and wrought aluminum products were reduced and are as follows: Unwrought in coils, 2.2 cents per pound; unwrought, other than aluminum silicon alloys, 1.2 cents per pound; and wrought in forms of bars, plates, sheets, and strip, 2.4 cents per pound.

Table 9.—U.S. exports of aluminum, by classes

Class	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Ingots, slabs, and crude	209,009	$99,961	180,279	$85,855
Scrap	54,531	17,686	49,427	16,017
Plates, sheets, bars, etc	96,275	70,757	114,062	77,418
Castings and forgings	2,816	11,178	3,527	10,104
Semifabricated forms, n.e.c	3,596	7,524	3,538	6,235
Total	366,227	207,101	350,833	195,629
Manufactures:				
Foil and leaf	3,612	5,940	4,070	6,937
Powders and pastes (aluminum and aluminum bronze) (aluminum content)	1,130	[r] 1,450	1,287	1,593
Wire and cable	11,143	8,560	11,635	10,177
Total	15,885	[r] 15,950	16,992	18,707
Grand total	382,112	[r] 223,051	367,825	214,336

[r] Revised.

Table 10.—U.S. exports of aluminum by classes and countries

Country	1967						1968					
	Ingots, slabs, and crude		Plates, sheets, bars, etc.[1]		Scrap		Ingots, slabs, and crude		Plates, sheets, bars, etc.[1]		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	9,037	$3,953	58	$104	---------	---------	9,970	$4,644	121	$69	---------	---------
Australia	105	70	1,083	1,034	366	$127	2,783	1,365	2,194	1,640	59	$18
Belgium-Luxembourg	22,604	11,139	261	364	264	86	32,509	14,631	204	292	215	59
Brazil	12,762	6,205	42	83	---------	---------	10,125	4,680	47	69	---------	---------
Canada	3,966	2,813	72,472	60,638	589	195	6,144	3,287	80,099	57,170	1,430	430
Chile	782	373	1,082	573	8	4	763	389	390	199	16	3
Colombia	3,144	1,526	50	92	---------	---------	6,632	3,183	103	95	---------	---------
El Salvador	738	359	322	202	14	2	1,134	634	215	128	---------	---------
France	14,846	6,488	295	402	34	7	12,085	5,673	654	611	266	88
Germany, West	14,976	6,944	1,827	1,774	15,835	4,947	8,459	4,064	3,548	3,523	17,947	5,656
Ghana	25	18	60	112	---------	---------	162	91	21	22	---------	---------
Hong Kong	1,325	504	87	102	44	8	2,196	1,076	122	122	45	15
India	12,736	5,774	1,326	708	---------	---------	3,452	1,594	71	85	---------	---------
Iran	2,174	1,103	207	191	---------	---------	2,604	1,274	200	205	3	1
Israel	1,177	452	1,008	662	---------	---------	881	423	465	671	---------	---------
Italy	2,378	1,206	2,660	4,479	13,214	4,159	377	189	1,978	3,120	7,437	2,429
Jamaica	45	34	251	272	2	1	144	90	157	179	---------	---------
Japan	37,073	17,261	2,964	2,696	18,456	6,272	20,389	8,736	2,734	2,842	13,478	4,340
Korea, South	8,098	3,770	43	47	28	13	9,195	4,552	21	27	589	158
Mexico	224	122	3,859	2,416	2	2	1,124	587	6,374	3,997	3	1
Netherlands	3,062	1,494	1,033	1,258	488	158	1,817	788	776	1,045	1,454	487
New Zealand	831	459	141	169	---------	---------	1,802	919	61	90	---------	---------
Pakistan	7,249	3,617	825	545	---------	---------	6,790	3,252	1,575	1,101	125	42
Panama	662	333	611	373	---------	---------	862	384	134	89	54	18
Peru	1,136	570	93	115	320	193	1,412	695	112	161	528	317
Philippines	4,657	2,310	49	85	50	16	7,046	3,583	27	51	15	7
South Africa, Republic of	1,742	854	921	621	---------	---------	2,868	1,429	1,968	1,391	---------	---------
Spain	1,379	650	439	475	361	85	723	470	235	793	307	67
Sweden	6,652	3,385	114	139	29	12	2,956	1,482	496	477	---------	---------
Switzerland	1,037	523	95	126	63	36	2,779	1,413	216	214	20	7
Taiwan	3,079	1,390	147	387	2,172	623	3,826	1,802	211	293	760	227
Thailand	3,189	1,288	102	129	---------	---------	2,897	1,530	29	45	---------	---------
United Kingdom	20,754	10,432	1,948	2,936	2,111	715	9,459	4,979	3,517	3,604	4,587	1,615
Venezuela	1,721	878	1,760	1,211	15	7	273	155	2,156	1,688	35	12
Vietnam, South	------	---------	2,872	1,340	---------	---------	---------	---------	6,655	3,969	---------	---------
Other countries	4,149	2,164	2,080	2,594	66	18	3,641	1,812	3,241	3,680	54	20
Total	209,009	99,961	102,687	89,454	54,531	17,686	180,279	85,855	121,127	93,757	49,427	16,017

---

[1] Includes plates, sheets, bars, extrusions, forgings and unclassified semifabricated forms.

Table 11.—U.S. imports for consumption of aluminum, by classes

Class	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude and semicrude:				
Metals and alloys, crude	449,716	$194,995	685,699	$298,759
Circles and disks	6,196	4,019	7,756	5,451
Plates, sheets, etc., n.e.c	33,770	25,809	42,243	27,311
Rods and bars	18,375	10,415	12,136	9,054
Scrap	30,489	10,040	37,521	12,134
Total	538,546	245,278	785,355	352,709
Manufactures:				
Foil	1,939	3,587	2,105	3,633
Leaf (5.5 by 5.5 inches)	([1])	17	([1])	16
Flakes and powders	496	388	289	270
Wire	571	610	715	582
Total	3,006	4,602	3,109	4,501
Grand total	541,552	249,880	788,464	357,210

[1] 1967: 1,542,500 leaves and 17,540,245 square inches of leaf; 1968: 2,624,000 leaves and 15,155,726 square inches of leaf.

Table 12.—U.S. imports for consumption of aluminum, by classes and countries

Country	1967						1968					
	Metal and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap		Metal and alloys, crude		Plates, sheets, bars, etc.[1]		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	------	---------	1,466	$1,096	---------	---------	---------	---------	249	$190	224	$71
Austria	------	---------	1,815	1,337	---------	---------	---------	---------	1,667	1,226	---------	---------
Belgium-Luxembourg	34	$19	17,381	10,741	---------	---------	---------	---------	9,486	5,678	185	57
Canada	356,209	154,208	6,474	5,465	29,164	$9,652	483,608	$210,301	6,436	4,829	27,924	8,738
France	2,918	1,268	2,971	2,197	---------	---------	11,521	4,861	5,917	5,259	---------	---------
Germany, West	117	79	2,401	2,181	---------	---------	(2)	1	2,858	2,110	30	7
Ghana	5,434	2,664	---------	---------	---------	---------	47,477	23,564	---------	---------	---------	---------
Greece	11,942	5,115	100	62	---------	---------	12,436	4,937	16	11	---------	---------
Italy	1	6	9,453	5,717	---------	---------	(2)	1	11,214	6,500	---------	---------
Japan	1,876	795	5,090	3,372	---------	---------	951	437	12,074	7,828	---------	---------
Norway	60,165	26,044	686	384	---------	---------	89,740	38,919	1,645	890	960	372
Poland	552	248	---------	---------	---------	---------	15,681	5,886	---------	---------	165	59
Spain	4,707	1,884	2,087	1,196	---------	---------	5,542	2,138	1,776	980	300	102
Sweden	------	---------	131	91	399	121	---------	---------	169	122	581	191
Switzerland	------	---------	r 164	164	---------	---------	3,858	1,440	188	173	---------	---------
United Kingdom	5,207	2,399	1,168	1,254	378	137	7,448	3,128	93	93	5,839	2,121
Venezuela	------	---------	---------	---------	---------	---------	2,227	1,002	---------	---------	857	314
Yugoslavia	------	---------	6,598	4,782	---------	---------	---------	---------	8,123	5,793	---------	---------
Other	554	266	356	204	548	130	5,210	2,144	224	134	456	102
Total	449,716	194,995	58,341	40,243	30,489	10,040	685,699	298,759	62,135	41,816	37,521	12,134

[1] Includes circles, disks, bars, rods, plates, sheets, etc.
[2] Less than ½ unit.

WORLD REVIEW

World primary aluminum output increased about 6 percent from that of the previous year compared with 10 percent between 1966 and 1967. Since 1964 the growth rate of primary aluminum production has been 6.25 percent, compounded annually. Japan consolidated its position as the world's fourth largest producer by increasing output 26 percent. Norway's increase of 30 percent pushed it past France as the fifth largest. The greatest gain, 175 percent, was registered by Ghana.

No new primary aluminum reduction plants were completed in the free world in 1968, but substantial additions were made to facilities in the United States, Mexico, Surinam, the Netherlands, Norway, and Japan. Capacities for world primary smelters at yearend 1968 are shown in table 14. Other primary plants scheduled for completion in 1969–1971 were to be located in Brazil, West Germany, Iceland, Italy, Norway, the United Kingdom, Angola, the Republic of South Africa, Bahrain, Iran, Japan, Australia, and New Zealand. A directory of aluminum ingot makers and semifabricators was available.[8]

Australia.—A prolonged drought in southwestern Australia, which caused hydroelectric power restrictions, seriously affected aluminum production in the first half of

---

[8] U.S. Department of Commerce, Business and Defense Services Administration. Foreign Free World Producers of Aluminum. Primary Ingot, Sheet, Plate, Foil and Extrusions. December 1968, 22 pp.

Table 13.—World production of aluminum by countries

(Short tons)

Country	1964	1965	1966	1967	1968 p
North America:					
Canada	842,640	830,505	r 889,915	975,439	984,999
Mexico	19,487	21,041	r 22,361	23,714	24,822
United States	2,552,747	2,754,478	2,968,366	3,269,259	3,255,042
South America:					
Brazil	29,366	33,518	r 29,637	e 40,000	e 45,700
Surinam [1]	---------	1,381	28,330	34,279	48,006
Venezuela	---------	---------	---------	3,407	11,000
Europe:					
Austria	85,646	86,880	87,002	86,801	94,687
Czechoslovakia e [2]	65,000	68,000	68,000	72,000	72,000
France	348,319	375,367	400,701	398,000	403,005
Germany:					
East e [2]	r 72,000	r 77,000	r 88,000	88,000	88,000
West	242,418	258,407	268,839	278,770	278,000
Greece	---------	---------	40,000	79,000	84,000
Hungary	62,693	64,043	66,685	68,118	69,000
Italy	127,422	136,660	r 140,864	140,851	156,912
Netherlands	---------	---------	22,422	e 35,000	54,000
Norway	287,724	303,804	356,809	397,915	518,174
Poland [2]	52,639	52,146	60,816	101,700	103,066
Rumania	---------	25,127	51,644	58,187	84,076
Spain	54,723	57,217	r 70,194	93,782	85,491
Sweden	33,589	34,959	r 31,613	37,809	61,509
Switzerland	70,805	74,020	75,756	79,697	84,718
U.S.S.R. e (primary)	900,000	930,000	980,000	1,064,000	1,100,000
United Kingdom	35,516	39,911	40,934	43,051	42,064
Yugoslavia	38,320	45,545	46,321	49,134	53,000
Africa:					
Cameroon, Republic of	56,777	55,652	53,681	53,488	50,035
Ghana	---------	---------	---------	43,752	120,044
Asia:					
China (mainland) e	110,000	110,000	110,000	90,000	99,000
India	62,465	74,041	91,803	106,210	132,387
Japan [3]	292,950	323,972	371,778	421,123	532,311
Taiwan	21,354	20,847	18,978	17,020	22,068
Oceania: Australia	88,194	96,744	101,262	102,286	107,308
Total [4]	r 6,552,794	r 6,951,265	r 7,582,711	8,351,742	8,864,424

e Estimate. p Preliminary. r Revised.

[1] Exports.

[2] Includes secondary.

[3] Includes super-purity: 1964, 2,136; 1965, 2,023; 1966, 2,361; 1967, 3,057; and 1968, 3,583.

[4] Totals are of listed figures only.

Lepanto completed plans for 150-tons-per-day mill which will be operational in 1969. High grade ore reserves of 175,000 tons averaging 3.5 ounces per ton in addition to 325,000 tons averaging 1.25 ounces of gold per ton and 4.0 percent copper were reported. Gold producers continued to receive subsidy payments.

South Africa, Republic of.—Production of gold from South African mines increased 2 percent to an alltime peak of 31.1 million ounces in 1968. Except for a slight decline in 1967, annual output has increased continuously since 1951. South Africa contributed about 78 percent of the total non-Communist gold production in 1968. The 48 gold-producing mines that were members of the Transvaal and Orange Free State Chamber of Mines milled 78.8 million tons of ore with an average yield of 0.39 ounce per ton. Mines in the Far West Rand, Klerksdorp, Orange Free State, and Evander areas accounted for nearly 85 percent of the total gold production. Working costs continued to rise. Despite increased production and the higher market price realized, working profits showed only a slight increase. A new plan of financial assistance to marginal gold mines was introduced by the South African Government. One mine closed during the year while two new mines, Elsburg and Kinross, completed the first full year's operation; the Kloof mine began productive operations in January. Payable ore reserves declined about 8 million tons to 159.1 million tons averaging 0.46 ounce per ton. The average number of employees in the gold mining industry was 40,491 whites and 368,135 nonwhites, a decline of 1,805 and an increase of 6,242, respectively.

Anglo American Corporation of South Africa Ltd. reported that gold production by its group of mines increased 3.5 percent to a record 12.54 million ounces, slightly more than 40 percent of South African production and nearly 31 percent of world production, excluding Communist countries. A total of 25.8 million tons of ore were milled, 2 percent more than in 1967. The seven Orange Free State mines of the group increased their production 2.4 percent to 8.2 million ounces, nearly 66 percent of the group output. The average recovery grade of these seven mines declined slightly to 0.55 ounce per ton owing mainly to the drop of 0.50 ounce in the grade at Western Holdings. Although the total tonnage of Anglo American's Transvaal mines was marginally lower, gold production increased nearly 6 percent to 4.3 million ounces. Costs per ton milled were lower at Western Reefs, but slightly higher at Western Deep Levels and Vaal Reefs. Western Deep increased the tons milled nearly 10 percent to 3.4 million and the yield per ton 0.04 ounce per ton to 0.55 ounce per ton. Ore reserves dropped 200,000 tons to 4.9 million tons but average grade increased to 593 inch-pennyweight (dwt), equivalent to 0.70 ounce per ton across a 42-inch stoping width. In addition, the ore reserve averaged 18.15 inch-pounds of uranium oxide.

Free State Geduld Mines Ltd. milled 1.96 million tons yielding 1.0 ounce per ton, a slight gain in tonnage and grade compared with 1967 levels. Working costs per ton increased slightly. The quantity and grade of ore reserves dropped slightly to 4.9 million tons averaging 1,119 inch-dwt (1.33 ounces across 42 inches).[12]

Union Corp. Ltd. reported a substantial increase in the quantity of ore milled and production of gold at its group of mines in 1968. Output totaled 13.0 million tons milled yielding 4.1 million ounces compared with 11.7 million tons and 3.6 million ounces in 1967. Production decreased at East Geduld and Grootvlei mines where operations are being slowly curtailed, but increased at all other mines of the group. Ore reserves at yearend increased 400,000 tons to 30.5 million tons averaging 0.37 ounce per ton. At East Geduld, tons milled dropped 50,000 to 929,000, but average yield per ton increased slightly to 0.21 ounce per ton; working costs remained virtually unchanged at $6.20 per ton. The ore reserve in the Main and Kimberley Reefs was 200,000 tons averaging 0.25 ounce per ton across 64 inches, and 500,000 tons averaging 0.23 ounce per ton across 51 inches, respectively. Grootvlei Proprietary Mines milled 2.4 million tons yielding 0.20 ounce per ton at a unit cost of $5.07, about the same yield and grade as in 1967. Yearend ore reserves on the Kimberley Reef increased 200,000 tons to 1.8 million tons averaging 0.22 ounce per ton across 51 inches but reserves on the Main Reef declined 800,000 tons to 1.4 million tons averaging 0.21 ounce per ton across a 54-inch width. St. Helena Mines reported a

---

[12] Anglo American Corp. of South Africa Ltd. Annual Report. 1968, pp. 15, 17, 61, 63.

Table 14.—World producers of aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Annual capacity, end 1968	Participants
FREE WORLD—Continued		
SOUTH AMERICA—Continued		
Surinam: Suriname Aluminum Co. (Suralco), Paranam	52	Alcoa.
Venezuela: Aluminio del Caroni, S.A. (Alcasa), Matanzas.	12	Reynolds Metals 50 percent; Government 50 percent.
Total South America	113	
EUROPE		
Austria:		
Salzburger Aluminium G.m.b.H. (SAG), Lend, Salzburg.	13	Alusuissee.
Vereinigte Metallwerke Ranshofen-Berndorf, A.G. (VMRB), Ranshofen.	82	Government.
Total	95	
France:		
Compagnie Péchiney (Péchiney):		
Auzat (Ariège)	23	
Chedde (Haute-Savoie)	9	
La Praz (Savoie)	4	
L'Argentière (Hautes-Alpes)	22	
La Saussaz (Savoie)	13	
Noguerés (Basses-Pyrénées)	121	
Rioupéroux (Isère)	24	
Sabart (Ariege)	24	
St. Jean de Maurienne (Savoie)	82	
Société d'Electrochimie, d'Electrometallurgie et des Acieries Electriques d'Ugine (Ugine):		Ugine-Kuhlman S.A.
Lannemezan (Hautes-Pyrénées)	61	
Venthon (Savoie)	30	
Total	413	
Germany, West:		
Aluminium-Hütte Rheinfelden G.m.b.H., Rheinfelden, Baden.	66	Alusuisse.
Vereinigte Aluminium-Werke A.G. (VAW):		Government.
Erftwerke, Grevenbroich	39	
Innwerke, Toging	77	
Lippewerke, Lunen	55	
Rheinwerke	50	
Total	287	
Greece: Aluminium de Grèce S.A. (ADG), Distomon	91	Péchiney 72 percent, Ugine 18 percent, Government 10 percent.
Italy:		
Alcan Alluminio Italiano S.p.A., Borgofranco d'Ivrea.	7	Alcan.
Montecatini-Edison S.p.A.:		
Bolzano	77	Government 11 percent.
Mori	25	Italian interests 89 percent.
Societe Alluminio Veneto per Azioni S.p.A. (SAVA):		
Portó Marghera	36	
Fusina	33	
Total	178	
Netherlands: Aluminium Delfzijl N.V. (Aldel) Delfzijl.	79	Hoogovens 50 percent, Alusuisse 33 percent, Billiton 17 percent.
Norway:		
A/S Ardal og Sunndal Verk (ASV):		
Ardal	126	Alcan 50 percent, Government 50 percent.
Hoyanger	32	
Sunndal	132	
Alnor A/S (Alnor) Karmoy Island	88	Norsk Hydro 51 percent, Harvey 49 percent.

See footnote at end of table.

Table 14.—World producers of aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Annual capacity, end 1968	Participants
FREE WORLD—Continued		
EUROPE—Continued		
Norway—Continued		
Det Norske Nitridaktieselskap (DNN):		
Eydehavn	13	Alcan 50 percent, British Aluminium 50 percent.
Tyssedal	24	
Mosjøen Aluminiumverk A/S (Mosal), Mosjøen	94	Alcoa 50 percent, Elektrokemisk A/S 50 percent.
Sør-Norge Aluminium A/S (Soral), Husnes	66	Alusuisse 67 percent, Norwegian interests 33 percent.
Total	575	
Spain:		
Aluminio de Galicia, S.A. (Alugasa), La Coruña	38	Péchiney 70 percent, Endasa 15 percent, Government 15 percent.
Aluminio Espanol S.A. (Alumespa), Sabinanigo, Huesca.	14	Péchiney.
Empresa Nacional del Aluminio, S.A. (Endasa):		
Avilés	20	Government 54 percent, Alcan 25 percent, Spanish interests 21 percent.
Valladolid	26	
Total	98	
Sweden: A/B Svenska Aluminiumkompaniet (Sako), Sundsvall, Kubikenborg.	72	Svenska Metallverken 79 percent, Alcan 21 percent.
Switzerland:		
Swiss Aluminium Ltd. (Alusuisse):		
Chippis	39	
Steg	33	
Usine d'Aluminium Martigny, S.A., Martigny	12	Giulini Bros.
Total	84	
United Kingdom: The British Aluminium Co., Ltd. (Baco Aluminium).		
Kinlochleven, Scotland	12	Tube Investments Ltd. 49.5 percent, Reynolds Metals Co. 48 percent.
Lochaber (Fort William), Scotland	29	
Total	41	
Yugoslavia: State-owned works:		
Kidričevo, Slovenia	55	
Lozovac	7	
Razine	5	
Total	67	
Total Europe	2,080	
AFRICA		
Cameroon, Republic of: Compagnie Camerounaise de l'Aluminium Péchiney-Ugine (Alucam), Edea.	57	Péchiney 48 percent, Ugine 12 percent, Cobeal 10 percent, Comal & Cie, 30 percent.
Ghana: Volta Aluminium Corp. (Valco), Tema	115	Kaiser 90 percent, Reynolds 10 percent.
Total Africa	172	
ASIA		
India:		
Aluminium Corp. of India Ltd. (Alucoin), Asansol, West Bengal.	10	
Hindustan Aluminium Corp. Ltd. (Hindalco), Renukoot, Uttar Pradesh.	66	Kaiser 27 percent, Birla and Indian interests 73 percent.
Indian Aluminium Co., Ltd. (Indal):		
Alupuram, Kerala	20	Alcan 65 percent, Indian interests 35 percent.
Hirakud, Orissa	24	
Madras Aluminium Co. Ltd. (Malco), Mettur, Madras.	13	Montecatini 27 percent, Government owned (Madras State) 73 percent.
Total	133	

See footnote at end of table.

Table 14.—World producers of aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Annual capacity, end 1968	Participants
FREE WORLD—Continued		
ASIA—Continued		
Japan:		
Mitsubishi Chemical Industries, Ltd.: Naoetsu	103	
Nippon Light Metal Co., Ltd. (NKK):		
Kambara	120	Alcan 50 percent, Japanese interests 50 percent.
Niigata	64	
Showa Denko K.K.:		
Chiba	68	
Kitakata	48	
Omachi	23	
Sumitomo Chemical Co., Ltd.:		
Isoura	53	
Kikumoto	35	
Nagoya	55	
Total	569	
Taiwan: Taiwan Aluminium Corp. (Taialco), Kaohsiung.	26	Government owned.
Total Asia	728	
OCEANIA		
Australia:		
Alcoa of Australia Pty. Ltd., Point Henry	45	Alcoa 51 percent, Western Mining Corp., Ltd. 20 percent, Broken Hill South Ltd. 17 percent, North Broken Hill Ltd. 12 percent.
Comalco Industries Pty. Ltd. (Comalco), Bell Bay, Tasmania.	82	Kaiser 50 percent, Conzinc Rio Tinto of Australia Ltd. 50 percent.
Total	127	
Total free world	7,951	
COMMUNIST COUNTRIES		
EUROPE		
Czechoslovakia: Ziar Aluminium Works, Ziar-on-Hron	68	State-owned.
Germany, East: Electrochemisches Kombinat:		
Bitterfeld	55	State-owned.
Lauta	20	
Total	75	
Hungary: Magyarsoviet Bauxite Ipar:		
Tatabánya	17	State-owned.
Ajka	22	
Inota	33	
Total	72	
Poland:		
Skawina Aluminium Works: Skawina	67	State-owned.
Konin Aluminium Works, Konin	52	
Total	119	
Rumania: Slatina	55	State-owned.
U.S.S.R.:		
Bogoslovsk (Krasnoturinsk), Sverdlovskaya, Oblast, Ural.	154	State-owned.
Bratsk, Irkutskaya Oblast, Siberia	165	
Irkutsk (Shelekhovo), Irkutskaya Oblast, Siberia	220	
Kamensk-Ural'skiy, Sverdlovskaya Oblast, Ural	149	
Kanaker (Yerevan), Armenia	83	
Kandalaksha, Murmanskaya Oblast	33	
Krasnoyarsk, Krasnoyarskiy Kray, Siberia	276	
Nadvoitsy, Karelskaya, A.S.S.R	39	

See footnote at end of table.

Table 14.—World producers of aluminum—Continued

(Thousand short tons)

Country, company, and plant location	Annual capacity, end 1968	Participants
COMMUNIST COUNTRIES—Continued		
EUROPE—Continued		
U.S.S.R—Continued		
Novokuznetsk (Stalinsk), Kemerovskaya Oblast, Siberia.	176	
Sumgait (Kirovabad), Azerbaijan	83	
Volgograd (Stalingrad), Volgogradskaya Oblast	138	
Volkhov (Zvanka), Leningrad Oblast	22	
Zaporozhye (Dneprovsk), Zaporozhskaya Oblast, Ukraine.	77	
Total	1,615	
ASIA		
China: Nationalized plants	110	
Total communist countires	2,114	
Total world	10,065	

[1] Increment by modernization at Quebec smelters (68,000 tons).

1968. The Comalco Industries Pty. Ltd. (Comalco) plant at Bell Bay, Tasmania, was forced to reduce output. A new half potline at this location had been installed by August 1967 but was not fully operative until October 1968 when the plant began producing at installed capacity.

Annual capacity at the Geelong (Point Henry) Victoria primary aluminum plant, owned by Alcoa of Australia Pty. Ltd., was being raised to 89,600 tons by 1970 and to 100,800 tons by 1971. Also, Alcan Australia Ltd. was building a new smelter at Kurri Kurri, 25 miles west of Newcastle in New South Wales. By 1969, capacity at this plant will be 30,000 tons, with a subsequent capacity of 50,000 tons.

Bahrain.—Aluminium Bahrain, Ltd. (Alba), consisting of five partners including the Bahrain Government (27½ percent), British Metal Corp. (25 percent), Sweden's Aktiebolaget Elektrokoppar (25 percent), Australia's Western Metals Corp. (12½ percent), and the British banker Guinness Mahon (10 percent), announced that a gas-fired, 63,000-ton-per-year primary aluminum smelter would be operating by 1971 on this island in the Persian Gulf. The Government agreed to grant a 20-year tax-free concession to the company.

Canada.—Production of 985,000 tons represented nearly the full installed capacity of Aluminum Company of Canada, a subsidiary of Alcan Aluminium Ltd. (Alcan), and Canadian British Aluminium Co. Ltd. (CBA). Because of demand, some potlines were reactivated at the Alcan plant in Alma, Quebec, and that in Kitimat, British Columbia.[9] Reynolds Metals Co. acquired British Aluminium Company's interest in CBA.

Czechoslovakia.—Péchiney agreed to construct a new aluminum complex with an initial capacity of 18,000 tons of aluminum per year at the Bridlicna works, North Moravia, to be ready in June 1971.

Germany, West.—Construction plans for new aluminum smelters along the Rhine River in North Rhine-Westphalia and in Baden-Wuerttemberg were announced. In the Ruhr Basin, Kaiser Aluminum & Chemical (Europe) GmbH planned to build a 65,000-ton-per-year plant by 1970 at Voerde in Dinslaken district. Also, Leichtmetallgesellschaft GmbH, Frankfurt, a new company equally shared by Metallgesellschaft A.G. and its subsidiary Vereinigte Deutsche Metallwerke A.G. of Frankfurt (VDM), and by Aluminium-Hütte Rheinfelden GmbH, Rheinfelden, and Aluminium-Walzwerke Singen GmbH, Signe/Hohentweil (both subsidiaries of Alusuisse) was founded to build a DM 250 million, 92,600 ton primary aluminum smelter in northwest Essen by the end of 1970.

---

[9] Jackson, W. H. Aluminum and Magnesium. Canadian Min. J., v. 90, No. 2, February 1969, pp. 116–118.

The Government-owned Vereinigte Aluminium-Werke A.G., (VAW), Bonn, planned to double the capacity of its Rhinewerke aluminum smelter near Neuss by 1970.

Gebr. Giulini GmbH., planned to build a 22,000-ton-per-year primary aluminum smelter at Ludwigshafen on the Rhine next to its 100,000-ton-per-year alumina plant.

The aluminum rolling mill, owned by Aluminium Norf GmbH (Alunorf), a joint partnership of Alcan Aluminiumwerke GmbH and VAW, went fully on stream. The hot mill, at Norf-Stuettgen, Rhineland, is the largest mill of its type in Europe with an initial capacity of 220,000 tons of reroll stock per year and is able to handle sheet ingot of over 17 tons each. Most of the sheet ingot was expected to come from Alcan's Norwegian partner, A/S Ardal og Sunndal Verk.

Greece.—Aluminium de Grece S.A. (ADG), a subsidiary of Compagnie Péchiney (Péchiney), said it will spend $14 million on facilities expected to raise production by September 1969 at the Distomon aluminum smelting plant on Antykira Bay, Gulf of Corinth.

Aristotle Onassis planned a $250 million alumina/aluminum plant to be placed in operation, probably near Messolonghi. Initial aluminum output would be 60,000 tons per year in 1975 and this would be doubled by 1978.

Iceland.—Icelandic Aluminum Co. Ltd., a subsidiary of Alusuisse, expected to complete a 36,000-ton-per-year aluminum smelter, the first in the country, at Straumsvik by 1972.

India.—It was reported that plans were being made to raise the capacity of the Renukoot smelter of Hindustan Aluminium Corp. Ltd. (Hindalco) to 132,000 tons. Also Madras Aluminium Co. Ltd. (Malco) planned to double capacity of its Mettur plant by 1971.

Italy.—A 110,000-ton-per-year aluminum reduction plant being built at Porto Vesme on the south coast of Sardinia by Alluminio Sarda (Alsar) will be the largest in Italy when fully completed in 1971. The depletion of domestic high-grade bauxite reserves, increasing imports of this material, and the presence of large deposits of leucite containing 17 to 18 percent alumina north of Naples, reportedly led EFIM, an Italian State-controlled holding company, to open negotiations for possibly using the U.S.S.R. licensed process for extracting alumina from aluminous igneous rocks such as nepheline syenites.

Japan.—Although this country is the world's fourth largest primary aluminum producer, there is a great dependence on imports. Near yearend the four primary producers were considering import of such material on a joint basis in order to exercise a greater control over import prices and quantities delivered.

By 1971, Mitsubishi Chemical Industries, Ltd. planned to expand capacity at Naoetsu, Niigata Prefecture, to 163,000 tons and will build a new 33,000- to 44,000-ton smelter at Sakaide, Shikoku Island. The primary smelter at Tomakomai, Hokkaido, being built by Nippon Light Metal Co. Ltd. (NKK), 50 percent of which is owned by Alcan and 50 percent by Japanese public shareholders, will have a 145,000-ton capacity when completed in 1972. Also, Sumitomo Chemical Co., Ltd. was expanding its capacity at Isoura and planning to build a 62,000-ton plant at Yoyama by early 1970. Showa Denko K.K. also raised production capacity at the Chiba and Omachi smelters.

Netherlands.—N.V. Billiton Maatschappij and Koninklijke Nederlandsche Hoogovens en Staalfabrieken (Royal Netherlands Blast Furnaces and Steelworks) announced formation of a jointly owned company, effective January 1, 1969, to coordinate and develop mutual aluminum interests such as their share in Aluminium Delfzijl N.V. (ALDEL), the only primary aluminum smelter in the country, the capacity of which was considerably enlarged in 1968.

New Zealand.—Comalco reached an agreement in July with the New Zealand Government in regard to a proposed $100.8 million primary smelter at Bluff, South Island. Owners will be Comalco (50 percent) and the Japanese firms, Showa Denko K.K. and Sumitomo Chemical Co. Ltd. (25 percent each). When the first stage is completed in 1971, the plant will be able to produce 78,000 tons per year. Shortly thereafter it will have a capacity of 118,000 tons per year, which will be doubled eventually.

Norway.—Hydroelectric power in this country, which has the highest per capita electricity consumption in the world, has been the mainstay of the country's aluminum industry. In looking to the future, however, Norsk Hydroelektrisk Kvaelstofaktieselskop (Norsk Hydro), one of the owners of Alnor A/S, was said to be cooperating with the National Electricity Board and the Institute for Nuclear Research on testing the feasibility of setting up a commercial atomic energy plant.

A/S Ardal og Sunndal Verk (ASV), which completed an expansion in 1968, announced a further expansion of 365,000 tons by 1971 by rebuilding the original potline, constructing a new anode plant, and expanding docking and storage facilities. Also, the company, with Det Norske Zinkkompani, will build a 20,000-ton-per-year aluminum fluoride plant near Odda by January 1970. This source of aluminum fluoride, which is an essential fluxing material in the electrolytic reduction of alumina, should supply all immediately foreseeable needs of Norwegian aluminum producers.

Plans were announced for expanding the new Alnor A/S plant at Haavik on Karmoy Island, western Norway, to 132,300 tons per year capacity by 1970. It was expected that capacity would be increased by extending the two current potlines, and eventually adding two more and constructing an alumina plant. Fabrication facilities at this site make the complex the first integrated aluminum plant in Norway.

Sufficient electric power to allow eventual production capacity of 110,000 tons at the Lista smelter owned by Elektrokemisk A/S (Elkem) was guaranteed by a royal decree signed in November 1968.

South Africa, Republic of.—Construction began late in the year on the Aluminium South Africa (Alusaf Pty. Ltd.) aluminum reduction plant at Richards Bay. The company is a venture of the Industrial Development Corp. of South Africa (IDC) and Alusuisse. Completion of the $67.4 million, 55,000-ton-per-year facility was scheduled for the middle of 1971.

Spain.—Empresa Nacional del Aluminio S.A. (Endasa), the country's largest primary aluminum producer, will be merged with Alcan Aluminio Iberico, S.A. (Aliberico), the leading aluminum fabricator, which is owned 60 percent by Alcan Aluminium Ltd. (Alcan). The agreement, which gives Alcan 25 percent in the combined company, was reached between Alcan and the Instituto Nacional de Industria (INI), the Spanish Government's industrial agency.

United Kingdom.—The Government granted Anglesey Aluminium Ltd. (a consortium of Rio Tinto—Zinc (RTZ) and British Insulated Callenders Cables Ltd. (BICC), 60 percent, and Kaiser Aluminum & Chemical Corp., 40 percent) permission to build a 112,000-ton aluminum reduction plant on Holy Island, near Holyhead, Anglesey, Wales. Electrical power will come from the proposed Wylfa nuclear station which will be located 14 miles from the aluminum plant site.

The British Aluminium Co. Ltd. (Baco Aluminium) received permission to construct a £37 million ($89 million), 112,000-ton aluminum smelter at Invergordon on the Moray Firth, Scotland. The plant, due to be in production in the first half of 1971, also will use nuclear power.

Alcan Aluminium (UK) Ltd., a wholly owned subsidiary of Alcan, planned to build a $120 million, 67,000-ton capacity aluminum smelter and coal-fired power station complex at Lynemouth, Northumberland, England, which would be in production by 1971.

Alcoa increased its interest in Imperial Aluminium Co. Ltd. (Impalco) from 50 to 75 percent by buying half the shares held by Imperial Chemical Industries Ltd. (ICI). Elkem bought the rest of the shares in Impalco held by ICI. Impalco operates a rolling mill and semifabricator, the largest European secondary smelter, a foil rolling company, and a materials handling company.

TECHNOLOGY

The relationship of carbon anodes and cathodes to the electrolytic preparation of aluminum was shown.[10] To keep impurities in the aluminum produced to a minimum, anodes having an extremely low ash content are used. These anodes are made from calcined petroleum coke or pitch coke. Voltage distribution and the hampering of ampere efficiency by aluminum mist being reoxidized to alumina by carbon monoxide in the aluminum reduction cells were discussed.

Aluminum diecasting techniques, one using low pressure and the other a so-called hot chamber process, were described.[11] The first method, using only 5 to 15 pounds per square inch gage (psig) to fill the die, is intended to help fill the gap between sand and pressure die castiing. It was said that low pressure die casting can be used for the majority of castings now produced by sand and permanent molding, but it has a slower cycle than pressure die casting. Hot chamber diecasting depends upon a new pump, with a cylinder and a plunger made from titanium diboride, which has high resistance to corrosive attack by the molten aluminum in which the pump is immersed. Castings up to 2.5 pounds were possible with this method and in the offing was a larger pump able to handle castings up to 4.5 pounds.

It was said that 15 forging alloys cover most applications.[12] They have good resistance to corrosion, and high strength-to-weight ratios. Forgings are available in three types—blocker type, closed-die forgings, and impact extrusions. Uses made of these types and techniques involved were discussed. A new forming process, called pierce forging, possibly may reduce production costs on nonferrous metal parts by as much as 35 percent.[13] Until recently used primarily for forming brass parts, it was used to form a flexible aluminum coupling produced from forging alloy 6262. Shapes and sizes of the parts are limited but production costs are lower and tensile strength higher than when the parts are made on screw machines.

Hypereutectic aluminum-silicon alloys, in which the silicon is present in an amount greater than that contained in the eutectic mixture of about 13 weight-percent silicon, are considered attractive for automotive applications, such as pistons and piston rings, cylinder and brake linings, and liner-free engine blocks, because of their low coefficient of thermal expansion and good wear resistance.[14] After aluminum powders with 25, 35, and 45 percent silicon were extruded and hot pressed, physical testing indicated that wear resistance rose and the coefficient of expansion decreased when the silicon content was increased from 25 to 45 percent.

New techniques for applying aluminum coatings to materials which are competitive with aluminum continued to be investigated. In building product applications, the steel industry believed that thin steel sheet hot-dip coated with aluminum would be an answer to competition from aluminum sheet.[15] Up to this time aluminum coatings had been applied by dipping, spraying, cladding, electroplating, vapor deposition, and as powders.[16] In a new method developed by Continental Oil Co. steel strip is heated and coated with aluminum diethyl hydride (ADEH) which then decomposes to an aluminum coating. This coating was said to have high purity, good adherence, satisfactory density, ductility, and corrosion resistance. In aerospace applications, where static charges which build up on reinforced plastic parts have to be dissipated, thin coatings of aluminum are being applied by "reverse bonding," a method which involves flame spraying a thin coating of aluminum on a mold and then bonding the metal coating to the slick plastic part.[17]

In melting aluminum scrap an oxy-fuel

---

[10] Light Metal Age. Carbon and the Light Metals. V. 26, Nos. 9–10, October 1968, pp. 21–28.

[11] Foundry. Pump is Key to Hot Chamber Aluminum Diecasting. V. 96, No. 12, December 1968, pp. 126–129.

Linderman, D. A. Low Pressure Aluminum Castings. Light Metal Age. V. 26, Nos. 11–12, December 1968, pp. 18–20.

[12] Michaels, Clifford A. Forging Aluminum for Everyday Applications. Metal Prog., v. 93, No. 5, May 1968, pp. 125–126, 128, 136, 138, 140, 142.

[13] Modern Metals. New Process Makes "Forgings" Direct from Molten Aluminum. V. 24, No. 1, February 1968, pp. 80–81.

[14] Skelly, Hugh M., and Cyril F. Dixon. Powders Beef-Up Al-Si Alloys. Metal Prog., v. 94, No. 5, November 1968, pp. 103–104.

[15] American Metal Market. Aluminized Steel Market Growth Expected. V. 75, No. 196, Oct. 10, 1968, pp. 1, 23.

[16] Iron Age. Aluminum Coatings: Search Goes On. V. 201, No. 3, Jan. 18, 1968, pp. 62–65.

[17] Product Engineering. Flame Throws Aluminum Coating on Resin-Impregnated Plastic. V. 39, No. 1, Jan. 1, 1968, pp. 82–83.

burner, developed by the Airco Industrial Gases Division of Air Reduction Co., was expected to increase melt rates by about 55 percent and cut metal loss by 26 percent. Alcan Aluminium Limited has installed such a burner on a reverberatory furnace at its Oswego, N.Y., plant. With the newly designed burner, oxygen consumption was lowered to a point where the technique becomes economically advantageous.[18]

---

[18] Metals Week. New Remelt System Boosts Rates, Cuts Loss. V. 39, No. 33, Aug. 12, 1968, p. 3.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/49

Antimony

By L. E. Davis [1]

The antimony market began in 1968 in a weak but seemingly stable condition, started firming late in the third quarter, and ended the year very tight. Domestic business was slow and ore prices remained unchanged until August, at which time only 60 and 65 percent ores were listed—and these at nominal quotations. By December, domestic ore quotations had been dropped by Metals Week as being unrealistic. Significantly, the August change coincided with the beginning of quotations for 60 percent European lump ore. This market had advanced 80 cents per unit by yearend.

Domestic mine production for 1968 was down, primary smelter production was only slightly higher than that for 1967, consumption was on the increase, and imports had virtually ceased due to an east coast dock strike.

Effective January 1, 1968, the "General Modification of Tariff Schedules of the U.S.," Federal Register Document 67-14749, filed on December 18, 1967, reduced the import duty on liquated antimony, TSUS No. 630.10, from 0.25 cent per pound to 0.20 cent, and on antimony metal, TSUS No. 632.02, from 2 cents per pound to 1.8 cents. Further reductions are scheduled—for liquated ore in 1970, and for metal each year through 1972.

Legislation and Government Programs.—Sales of 240 tons of surplus antimony were made by General Services Administration in 1968, under authorization of Public Law 88-615 enacted in 1964. Of the total, 155 tons was antimony metal, all grades; the remaining 85 tons was liquated ore. From the initial disposal authorization of 5,000 tons, 2,383 tons remained for sale at yearend. Total government inventory was 49,197 tons at the close of 1968, 23,697 tons of which was excess held because of market impact. The stockpile also contained 10,336 tons of antimonial lead, including quantities that had been committed but not shipped, for which there are no stockpile objectives.

---

[1] Physical scientist, Spokane Office of Mineral Resources.

Table 1.—Salient antimony statistics

(Short tons)

	1964	1965	1966	1967	1968
United States:					
Production:					
Primary:					
Mine	632	845	927	892	856
Smelter [1]	13,358	12,389	14,539	12,466	12,489
Secondary	22,339	24,321	24,258	23,664	23,699
Exports of ore, metal and alloys	807	14	29	82	109
Imports, general (antimony content)	16,718	14,879	19,712	17,419	17,343
Consumption [1]	15,839	16,919	19,681	17,350	18,520
Price: New York, average cents per pound	42.22	45.75	45.75	45.75	45.75
World: Production	69,403	69,456	67,627	63,849	67,767

[1] Includes primary antimony content of antimonial lead produced at primary lead smelters.

DOMESTIC PRODUCTION

MINE PRODUCTION

Antimony production in 1968 virtually was limited to that produced as cathode metal in the electrolytic plant of Sunshine Mining Co., Coeur d'Alene district, Idaho. The source for the metal was silver ores from the Sunshine mine and adjacent properties. Overall output was 4 percent below that of 1967. The company disclosed plans to build a new antimony plant in conjunction with a proposed silver refinery at the mine site. The antimony plant would be built even if a feasibility study, being conducted by the Colorado School of Mines on the silver refinery, proves negative. Results of the study are expected in March 1969.

Antimony concentrates containing about 3 tons of metal were produced and stockpiled at the Stampede mine, Kantishna district, Alaska, but no shipments were made. Concentrates assaying 45 percent antimony, produced in previous years from ore of the Stibnite mine, Sanders County, Mont., were shipped to the Laredo smelter. The mine was idle throughout 1968.

The first authenticated discovery of zinkenite, a rare lead-antimony mineral, in Washington was made at the Wells Fargo mine, Stevens County. The sample tested was taken by a geologist of the Washington State Division of Mines and Geology from an outcrop above the main adit. A spokesman for the mining company stated that the 500-foot adit had uncovered a high-grade ore vein on the last working day before winter closed the operation down. An assay of 25 percent lead, 23 percent zinc, 21 percent antimony, 1 percent arsenic, and nearly 13 ounces of silver and 0.04 ounce of gold per ton was reported. A second vein containing 45.7 percent antimony was said to have been cut at the 485-foot point in the adit. Plans were announced to drift and raise on these ore zones as soon as weather permitted in 1969.

SMELTER PRODUCTION

Primary.—Production of antimony metal, oxide, and other products totaled only a few tons above the 1967 figure. Domestic sources supplied 18 percent of the total, chiefly as a coproduct from silver ores or as a byproduct of lead ores. Foreign antimony ores and concentrates or byproduct antimony from foreign lead ores yielded 82 percent of the primary production. Most of the byproduct antimony recovered at primary lead refineries was consumed at the refineries in the manufacture of antimonial lead. A relatively small quantity was processed to oxide. Primary smelter products were divided as follows: Oxide, 52 percent; metal, 29 percent; antimonial lead, 15 percent; and sulfide and residues, 4 percent.

National Lead Co. at Laredo, Tex., and Sunshine Mining Co. in the Coeur d'Alene district, Idaho, produced antimony metal. M & T Chemicals, Inc.; Harshaw Chemical Co.; and McGean Chemical Co. were the major producers of antimony oxide while a high percentage of ore for consumption as a sulfide was processed by Foote Mineral Co. and Hummel Chemical Co. American Smelting and Refining Company was the leading producer of byproduct antimony.

Secondary.—Secondary antimony recovery, from lead scrap, was only slightly more than in 1967—less than 20 tons at primary lead smelters and less than 200 tons at secondary lead plants. Manufacturers and foundries recovered 669 tons of antimony in processing manufacturing scrap, about 170 tons below that in 1967. Old scrap sources contributed 89 percent of the total secondary antimony and consisted of the following: Batteries, 67 percent; type metal, 22 percent; babbit, 5 percent; and miscellaneous material, 6 percent. Drosses and residues were virtually the only sources for secondary antimony recovered from new scrap, representing 11 percent of the total. Nearly 3,440 tons of primary antimony was required to supplement the secondary metal available in order to meet commercial requirements; this was about 90 tons more than in 1967.

Table 2.—Antimony mine production and shipments in the United States

(Short tons)

Year	Antimony concentrate	Antimony	
	Quantity	Produced	Shipped
1964	3,296	632	789
1965	4,711	845	848
1966	5,582	927	930
1967	5,402	892	828
1968	5,268	856	941

Table 3.—Primary antimony produced in the United States

(Short tons, antimony content)

Year	Class of material produced					
	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1964	4,418	6,748	53	447	1,692	13,358
1965	4,216	6,485	94	205	1,389	12,389
1966	4,567	7,794	126	219	1,833	14,539
1967	4,002	6,612	71	249	1,532	12,466
1968	3,617	6,518	133	417	1,804	12,489

Table 4.—Secondary antimony produced in the United States, by kind of scrap and form of recovery

(Short tons, antimony content)

Kind of scrap	1967	1968	Form of recovery	1967	1968
New scrap:			In antimonial lead [1]	16,783	17,365
Lead-base	2,516	2,586	In other lead alloys	6,865	6,309
Tin-base	91	86	In tin-base alloys	16	25
Total	2,607	2,672	Total	23,664	23,699
Old scrap:			Value (millions)	$21.7	$21.7
Lead-base	21,031	20,998			
Tin-base	26	29			
Total	21,057	21,027			
Grand total	23,664	23,699			

[1] Includes 185 tons of antimony recovered in antimonial lead from secondary sources at primary plants in 1967 and 203 tons in 1968.

Table 5.—Byproduct antimonial lead produced at primary lead refineries in the United States

(Short tons)

Year	Gross weight	Antimony content				
		From domestic ores [1]	From foreign ores [2]	From scrap	Total	
					Quantity	Percent
1964	24,023	997	695	303	1,995	8.3
1965	27,895	998	391	595	1,984	7.1
1966	24,059	1,417	416	286	2,119	8.8
1967	18,608	983	549	185	1,717	9.2
1968	28,363	1,300	504	203	2,007	7.1

[1] Includes primary residues and a small quantity of antimony ore.
[2] Includes foreign base bullion and small quantities of foreign antimony ore.

CONSUMPTION AND USES

Industrial requirements for antimony were derived from both primary and secondary sources. Total consumption rose to 42,220 tons in 1968 from 41,010 in 1967. Primary antimony represented nearly 44 percent of the total (18,520 tons), and secondary metal was 56 percent (23,700 tons). Virtually all secondary antimony was consumed in the manufacture of antimonial lead and other hard-lead alloys.

The Bureau of Mines collects statistics on industrial consumption, by use, for primary antimony only, and tables 6 and 7 are limited to that information.

Primary antimony consumption was nearly 7 percent above the comparable 1967 figure but well below the record high attained in 1966. Antimony requirements for metal products rose above 9,000 tons to the highest level since 1953. Most notable was the quantity used in antimonial lead; this was a higher tonnage than in any year since 1953, despite the increase in secondary antimony and the continued reduction in antimony content of battery plates. Increased consumption also was reported for all other metal products except ammunition, castings and sheet and pipes.

The quantity of antimony used in nonmetal products dropped for the second consecutive year, although increases were recorded for use in plastics, ceramics and glass, and pigments. Of the nearly 980 tons listed under "other" nonmetal products, more than 50 percent was Leukonin (sodium meta antimonate) used as an opacifier in formulating enamel frits. An additional 14 percent of this total was consumed as antimony trichloride, which has a wide variety of applications.

Consumption data for 1968 appears to be a deviation from the normal trend; however, present military needs tend to obscure usual patterns. A lower antimony content in many metal products is offset by a greater demand for the products; for nonmetal products, the use of substitute materials appears to have leveled the gradual rise in antimony consumption. The trend should become more evident with a persistent tight market and a further advance in prices.

Table 6.—Industrial consumption of primary antimony in the United States

(Short tons, antimony content)

Year	Class of material consumed						
	Ore and concentrate	Metal	Oxide	Sulfide	Residues	Byproduct antimonial lead	Total
1964	252	6,050	7,325	73	447	1,692	15,839
1965	404	6,992	7,847	81	206	1,889	16,919
1966	450	6,269	10,829	81	219	1,883	19,681
1967	812	5,666	9,514	77	249	1,582	17,350
1968	299	6,561	9,363	75	418	1,804	18,520

Table 7.—Industrial consumption of primary antimony in the United States, by class of material produced

(Short tons, antimony content)

Product	1964	1965	1966	1967	1968
METAL PRODUCTS					
Ammunition	15	36	154	209	156
Antimonial lead	5,952	6,382	6,285	5,539	6,817
Bearing metal and bearings	804	821	731	658	755
Cable covering	49	68	164	141	178
Castings	50	76	62	54	46
Collapsible tubes and foil	53	49	44	31	50
Sheet and pipe	99	104	107	118	105
Solder	149	244	155	184	255
Type metal	513	642	515	382	423
Other	167	214	219	223	258
Total	7,851	8,636	8,436	7,534	9,043
NONMETAL PRODUCTS					
Ammunition primers	17	16	27	30	33
Fireworks	47	46	50	43	37
Flameproofing chemicals and compounds	1,626	1,971	3,188	3,454	2,774
Ceramics and glass	1,649	1,853	2,074	1,884	2,037
Matches	W	W	--------	--------	--------
Pigments	1,178	855	832	665	859
Plastics	1,289	1,469	2,224	1,785	2,318
Rubber products	492	477	870	948	440
Other	1,695	1,596	1,980	1,007	979
Total	7,988	8,283	11,245	9,816	9,477
Grand total	15,839	16,919	19,681	17,350	18,520

W Withheld to avoid disclosing individual company confidential data; included with "Other."

STOCKS

Industrial stocks of antimony, as reported to the Bureau of Mines, dropped to the lowest level since 1962. While ore and concentrate stocks were the highest since 1959, metal stocks declined to a 10-year low and antimonial lead stocks to an 8-year low. Oxide was in short supply at yearend and stocks were lower than in any period since 1963. In the latter part of the year, a very high demand for antimonial lead for use in the manufacture of automotive batteries was a major factor in reducing industrial stocks nearly 21 percent compared with 1967. To a lesser extent, the east coast dock strike that virtually halted imports contributed to the overall decline in metal and oxide stocks.

Table 8.—Industry stocks of primary antimony in the United States, December 31

(Short tons, antimony content)

Stocks	1964	1965	1966	1967	1968
Ore and concentrate	1,647	2,735	2,720	2,469	2,791
Metal	1,433	1,585	1,572	1,719	1,323
Oxide	2,895	2,705	3,093	2,704	1,921
Sulfide	81	98	131	80	127
Residues and slags	935	1,088	519	916	199
Antimonial lead [1]	309	411	531	462	265
Total	7,300	8,622	8,566	8,350	6,626

[1] Inventories from primary sources at primary lead smelters only.

PRICES

Domestic ore prices were quoted in the range $5.00 to $5.95 per short ton unit at the beginning of the year, depending on quality, and remained unchanged until August. At that time only 60 and 65 percent ores were listed and at nominal quotations. In December domestic ore quotations were dropped by Metals Week as being unrealistic. At yearend Engineering and Mining Journal listed 60 percent domestic ores at $5.80 per short ton unit and 65 percent at $5.90.

The August change in listings for domestic ores coincided with the beginning of quotations for 60 percent European lump ores. This market began at $6.20 to $6.30 per long ton unit and had advanced to $7 to $7.10 by December 30. The latter quotation is the equivalent of $6.25 to $6.34 per short-ton unit. The domestic quotation for 99.5 percent antimony metal, in bulk at New York, remained unchanged at 45.75 cents per pound. Imported metal of equal grade, duty paid at New York in 5-ton lots, began the year at 41.5 to 42.0 cents per pound and rose to 43.5 to 44.0 cents. Oxide was quoted at 47.5 cents per pound in carload lots throughout the year.

Table 9.—Antimony price ranges in 1968

	Price
Type of antimony:	
Domestic metal [1] per pound	$0.44
Foreign metal [2] do	.40–.44
Antimony trioxide [3] do	.475
Antimony ore,[3] 50–55 percent per short-ton unit	[4] 5.00–5.40
Antimony ore, minimum 60 percent do	[5] 5.80–5.85
Antimony ore, minimum 65 percent do	[5] 5.90–5.95

[1] RMM brand, f.o.b., Laredo, Tex.
[2] Duty-paid delivery, New York.
[3] Quoted in Metals Week.
[4] Quotations discontinued August 1968.
[5] Quotations discontinued December 1968.

FOREIGN TRADE

Antimony exports—metal, alloys, waste, and scrap—totaled 109 tons, appreciably above the 82 tons exported in 1967. However, value of the exports dropped $20,000 to less than $55,000. Consignments were made to 20 countries. Ethiopia was the leading importer with 56 tons, followed by Canada at 18 tons. The quantity and value of antimony oxide exports declined noticeably to 119 tons and $101,300. Canada received 61 tons and Japan 28 tons. The balance was divided among nine other countries.

General imports (17,343 tons, antimony content) in all forms were only 76 tons below the 1967 figure. All but 11 tons of metal was entered for consumption. In all categories except oxide, imports were higher. Less ore and concentrates were received, tonnagewise, but the metal content was greater. The Republic of South Africa, Mexico, and Bolivia supplied a high percentage of ore imports (97 percent based on metal content). Yugoslavia and Belgium-Luxembourg were the principal sources for metal imports (66 percent). The United Kingdom and Belgium-Luxembourg were the major suppliers of oxide (74 percent).

Additional imports included 714 tons of alloy containing 83 percent or more antimony by weight, nearly half of which came from Peru; 107 tons of tartar emetic

Table 10.—U.S. imports[1] of antimony, by countries

Year and country	Antimony ore			Antimony metal [2]		Antimony oxide	
	Short tons (gross weight)	Antimony content		Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)
		Short tons	Value (thousands)				
1966	26,229	12,460	$4,754	2,805	$2,052	5,383	$3,998
1967:							
Belgium-Luxembourg	-------	-------	-------	807	585	1,928	1,461
Bolivia	3,946	2,439	1,155	5	3	-------	-------
Canada	-------	-------	-------	(3)	17	-------	-------
Chile	831	507	220	-------	-------	-------	-------
France	-------	-------	-------	-------	-------	699	514
Germany, West	-------	-------	-------	11	9	170	124
Mexico	10,369	3,018	570	204	101	-------	-------
Morocco	334	164	42	-------	-------	-------	-------
Mozambique	112	69	33	-------	-------	-------	-------
Netherlands	-------	-------	-------	-------	-------	39	30
Peru	198	131	52	58	34	-------	-------
South Africa, Republic of	6,751	4,117	2,003	-------	-------	-------	-------
Thailand	106	72	15	94	42	-------	-------
Turkey	-------	-------	-------	11	7	-------	-------
United Kingdom	-------	-------	-------	283	200	2,262	1,633
Yugoslavia	-------	-------	-------	1,208	868	-------	-------
Total	22,647	10,517	4,090	2,681	1,866	5,098	3,762
1968:							
Algeria	43	15	5	-------	-------	-------	-------
Belgium-Luxembourg	-------	-------	-------	598	476	1,336	1,033
Bolivia	3,979	2,521	1,139	33	18	-------	-------
Canada	-------	-------	-------	(3)	16	-------	-------
Chile	77	51	26	12	4	9	5
France	-------	-------	-------	50	30	869	655
Germany, West	-------	-------	-------	(3)	2	183	135
Honduras	250	98	44	-------	-------	-------	-------
Italy	-------	-------	-------	11	7	-------	-------
Japan	-------	-------	-------	-------	-------	119	82
Mexico	8,664	2,606	459	255	146	-------	-------
Morocco	198	75	28	-------	-------	-------	-------
Netherlands	-------	-------	-------	-------	-------	58	45
Peru	77	52	21	133	87	-------	-------
South Africa, Republic of	8,389	5,196	2,423	-------	-------	-------	-------
Thailand	-------	-------	-------	155	105	-------	-------
United Kingdom	-------	-------	-------	288	224	2,227	1,585
Yugoslavia	-------	-------	-------	1,229	972	-------	-------
Total	21,677	10,614	4,145	2,764	2,087	4,801	3,540

---

[1] Data are general imports: that is, they include antimony imported for immediate consumption plus material entering bonded warehouses.

[2] Includes data for needle or liquated antimony for the following countries (value in thousands); 1967, United Kingdom, 5 tons ($4); 1968, 15 tons ($10); 1967, Belgium-Luxembourg, 24 tons ($14); 1968, 45 tons ($32). Does not include alloy containing 83 percent or more of antimony.

[3] Less than ½ unit.

(potassium antimony tartarate) from Italy and Japan; 35 tons of other antimony alloys, received principally from France; 21 tons of other antimony compounds, 82 percent of which was supplied by the United Kingdom; and 10 tons of antimony sulfide from Peru. Total value of these materials was $732,700.

Table 11.—U.S. imports for consumption of antimony

Year	Antimony ore			Needle or liquated		Antimony metal [1]		Antimony oxide	
		Antimony content							
	Short tons (gross weight)	Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)	Short tons (gross weight)	Value (thousands)
1966	26,229	12,460	$4,754	63	$42	2,767	$2,031	5,383	$3,998
1967	22,647	10,517	4,090	29	18	2,654	1,849	5,098	3,762
1968	21,677	10,614	4,145	60	42	2,693	2,037	4,801	3,540

[1] Does not include alloy containing 83 percent or more of antimony; 1966: Peru 101 short tons ($59,417), United Kingdom 153 short tons ($89,145); 1967: Mexico 50 short tons ($39,139), Peru 122 short tons ($70,553), United Kingdom 140 short tons ($79,636) Belgium-Luxembourg 11 short tons ($7,882), Czechoslovakia 33 short tons ($18,383); 1968: Mexico 193 short tons ($157,102), Peru 351 short tons ($230,845), United Kingdom 87 short tons ($55,894), France 24 short tons ($14,528), Japan 59 short tons ($35,345).

WORLD REVIEW

The world supply-demand situation for antimony began 1968 in a delicately balanced position and the market was weak. Before the year ended, demand was at a high level and the market became very tight. Marked price increases were reported in South American and European markets; yet, among major producing countries, only the Republic of South Africa reported a production increase. Chinese offerings were sparse. Sales at the Canton Trade Fairs were small; virtually all was purchased by Japanese industry. Antimony refiners in Japan covered their 1968 needs through contracts with Bolivia, Republic of South Africa, and mainland China. No attempt was made to hold off spot purchases of antimony ore because of high prices. The Japanese firm Hibino-Metal Industry Co. stated it had purchased 3,000 tons of ore from mainland China to cover its antimony needs during the first half of 1969, and hoped to buy another 3,000 tons at the April 1969 Canton Trade Fair. Total 1968 imports by the company included 1,300 tons of Chinese ore bought at the autumn Canton Trade Fair. Hibino planned to double its 1969 production, employing a new process enabling the use of low-grade ores with 30 to 40 percent antimony content.

A full year's capacity operation by Consolidated Murchison Goldfields and Development Co., Ltd., Republic of South Africa, resulted in a marked rise in production of antimony concentrates and cobbed ore. Bolivian and Mexican outputs were below 1967 despite high demand and rising prices. A planned change in the antimony extraction process in Peru was not culminated and, although higher than in 1967, production was not up to the 1964 level.

TECHNOLOGY

The results of recent research at Gould–National Batteries, Inc., Minneapolis, Minn., were published.[2] The work shows a correlation between microstructure, hardness, castability, corrosion behavior, and resistivity in a linear as well as logical manner. If battery performance, such as life expectancy, is emphasized, 0 to 5 percent arsenic in antimony-lead is recommended. The findings are more or less borne out by information received from Sunshine Mining Co. Some company customers alloy the unrefined cathode anti-

---

[2] Mao, F. W., and J. G. Larson. Effect of Arsenic Additions on Characteristics of Antimony–Lead Battery Alloy. Metallurgia, v. 78, December 1968, 236–245.

Table 12.—World production of antimony (content of ore except as indicated) by countries

(Short tons)

Country	1964	1965	1966	1967	1968 ᵖ
North America:					
Canada [1]	796	651	703	634	562
Guatemala	--------	--------	15	33	17
Honduras	--------	--------	--------	--------	286
Mexico [2]	ʳ 5,279	4,917	4,868	4,121	3,819
United States	632	845	927	892	856
South America:					
Bolivia [2]	ʳ 10,648	ʳ 10,615	ʳ 11,760	12,432	12,188
Peru (recoverable)[2]	752	713	741	ʳ 700	739
Europe:					
Austria (recoverable)	585	434	250	212	178
Czechoslovakia ᵉ	ʳ 1,300	ʳ 1,300	ʳ 1,300	1,200	1,200
France	119	133	308	181	NA
Italy	304	293	292	405	865
Portugal	13	12	4	25	ᵉ 44
Spain	60	95	100	185	147
U.S.S.R.ᵉ	6,700	6,800	6,900	7,000	7,000
Yugoslavia (metal)	3,008	3,051	2,916	2,533	1,935
Africa:					
Algeria	--------	71	ʳ 103	129	ᵉ 123
Morocco	1,720	2,425	1,480	1,758	1,336
Rhodesia, Southern	49	ᵉ 200	NA	NA	NA
South Africa, Republic of	14,200	13,901	12,534	13,666	18,511
Asia:					
Burma ᵉ [2]	ʳ 110	ʳ 110	ʳ 110	88	99
China, mainland ᵉ	16,500	16,500	16,500	13,200	13,200
Japan	ʳ 172	ʳ 63	ʳ 26	19	21
Korea, South	--------	--------	64	73	34
Pakistan	90	67	NA	NA	NA
Sarawak	86	61	65	34	ᵉ 22
Thailand ᵉ	1,399	1,246	1,177	1,181	208
Turkey [3]	3,631	3,896	3,396	2,244	3,446
Oceania: Australia [4]	1,250	1,057	1,088	1,009	931
Total [5]	ʳ 69,403	ʳ 69,456	ʳ 67,627	63,849	67,767

ᵉ Estimate. ᵖ Preliminary. ʳ Revised. NA Not available.

[1] Antimony content of smelter products.

[2] Includes antimony content of smelter products derived from mixed ores.

[3] Includes ore and concentrates.

[4] Includes antimony in lead concentrates.

[5] Total is of listed figures only.

mony metal, which contains a very small percentage of arsenic, with lead to produce a good-quality battery plate.

Gray iron alloyed with antimony is useful as a very inexpensive bearing material, according to the Odessa Institute of Technology, Odessa, U.S.S.R.[3] The composition is 3.0 to 3.5 percent carbon, 1.4 to 2.2 percent silicon, 0.6 to 0.8 percent manganese, 0.3 to 0.65 percent antimony, and less than 0.3 percent phosphorus and 0.12 percent sulfur, with the antimony added to the ladle. Addition of the antimony reportedly give the iron outstanding friction characteristics and a slight increase in hardness that does not affect machinability. Cast iron alloyed with antimony has a very fine grain, with a microstructure characterized by fine lamellar perlite and uniformly distributed "nests" of graphite. Owing to the presence of graphite and antimony, the iron is "greasy" and does not seize, even when lubrication is inefficient. Field trial reports have shown service life of the iron bearings to be twice or three times as long as that of bronze bearings.

An item in the 1968 Annual Report of the American Smelting and Refining Company states that a high-purity metals facility, under construction at its Globe plant, Denver, Colo., will be completed in 1969. The plant will produce high-purity elements used primarily for metallurgical research. Antimony was one of the elements listed.

---

[3] Foundary. October 1968, p. 28.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/39

Asbestos

By Paul W. Icke[1]

The demand for asbestos increased in 1968 primarily as a result of a rise in construction activity and automobile production. Despite the increased demand in these two important sectors, U.S. production (shipments) of asbestos declined 2 percent. However, a 14-percent increase in imports covered rising U.S. requirements. Canada, the largest producer, increased output (sales) by 10 percent over that of 1967.

Legislation and Government Programs.—The General Services Administration (GSA) in 1968 disposed of 1,250 short tons of amosite, 189 tons of crocidolite, and 1,242 tons of domestic chrysotile from government inventories.

Table 1.—Salient asbestos statistics

	1964	1965	1966	1967	1968
United States:					
Production (sales) short tons	101,092	118,275	125,928	128,189	120,690
Value thousands	$8,143	$10,162	$11,056	$11,102	$10,406
Exports and reexports (unmanufactured) short tons	27,147	43,126	46,996	47,718	41,236
Value thousands	$3,199	$5,294	$5,763	$6,025	$4,679
Exports and reexports of asbestos products (value) thousands	$16,288	$19,139	$21,963	$23,767	$24,527
Imports for consumption (unmanufactured) short tons	739,361	719,559	726,459	645,112	737,909
Value thousands	$72,973	$70,457	$78,100	$65,748	$72,930
Consumption, apparent [1] short tons	813,306	794,708	805,391	720,583	817,368
World: Production do	3,050,900	3,101,994	3,275,262	3,094,784	NA

NA Not available.
[1] Measured by quantity produced, plus imports, minus exports.

Table 2.—Stockpile objective and Government inventories as of December 31, 1968

(Short tons)

Mineral	Stockpile objective	Inventories: National	Inventories: Supplemental	Inventories: Defense Production Act	Inventories: Total
Amosite	40,000	11,705	53,606	--------	65,311
Chrysotile	13,700	6,080	4,383	--------	10,463
Subspecification	--------	152	3,193	1,536	4,881
Crocidolite	--------	1,565	46,507	--------	48,072

---

[1] Physical scientist, Division of Mineral Studies.

DOMESTIC PRODUCTION

Asbestos production in the United States in 1968 declined 2 percent in volume and 6 percent in value. Production in California decreased from 77,091 tons in 1967 to 75,592 tons in 1968, and the value dropped by $587,000. Output in Arizona increased 34 percent, while production in Vermont decreased almost 5 percent. North Carolina, the smallest producer, continued its downward trend with a decrease of 20 percent from the previous year's production.

Practically all U.S. production was short fiber, which supplied approximately 14 percent of domestic requirements. U.S. producers are listed in the following tabulation:

State and company	County	Name of mine	Type of asbestos
Arizona:			
Asbestos Manufacturing Co	Gila	Phillips	Chrysotile.
Jaquays Mining Corp	do	Chrysotile	Do.
Metate Asbestos Corp	do	Lucky Seven	Do.
California:			
Atlas Minerals Corp	Fresno	Santa Cruz	Do.
Coalinga Asbestos Co	do	Coalinga	Do.
Pacific Asbestos Corp [1]	Calaveras	Pacific Asbestos	Do.
Union Carbide Corp	San Benito	Joe No. 5	Do.
North Carolina:			
Powhatan Mining Co	Yancey	Burnsville	Anthophyllite.
Vermont:			
General Aniline & Film Corp. (The Ruberoid Division).	Orleans	Lowell	Chrysotile.

[1] Acquired by H. K. Porter Co. Inc. during 1968.

The U.S. Geological Survey discovered a chrysotile asbestos deposit in the Yukon-Tanana Upland near Eagle, Alaska. It is located some 55 miles northwest of the Cassair Clinton mine in Yukon Territory, Canada.[2]

CONSUMPTION AND USES

The commercial utility of asbestos was originally based on the heat resistance characteristics of the fibrous mineral for use in packings. Its current utility is based more on its ability as a reinforcing binder in such products as portland cement, rubber, and plastics. The asbestos cement industry was the largest consumer, requiring an estimated 50 percent of the world's asbestos production. The second largest use was in the floor tile industry, with an estimated U.S. consumption of 200,000 tons. Other important uses were in the manufacture of brake linings, millboard products, gaskets, clutch facings, electrical and heat insulations, and textiles. Chrysotile asbestos accounted for 96 percent of the total amount consumed in the United States in 1968, crocidolite accounted for slightly less than 2 percent, and amosite accounted for slightly over 2 percent.

---

[2] Foster, H. L. Asbestos Occurrence in the Eagle C–4 Quadrangle, Alaska. U.S. Geol. Survey Circ. 611, 1969, 7 pp.

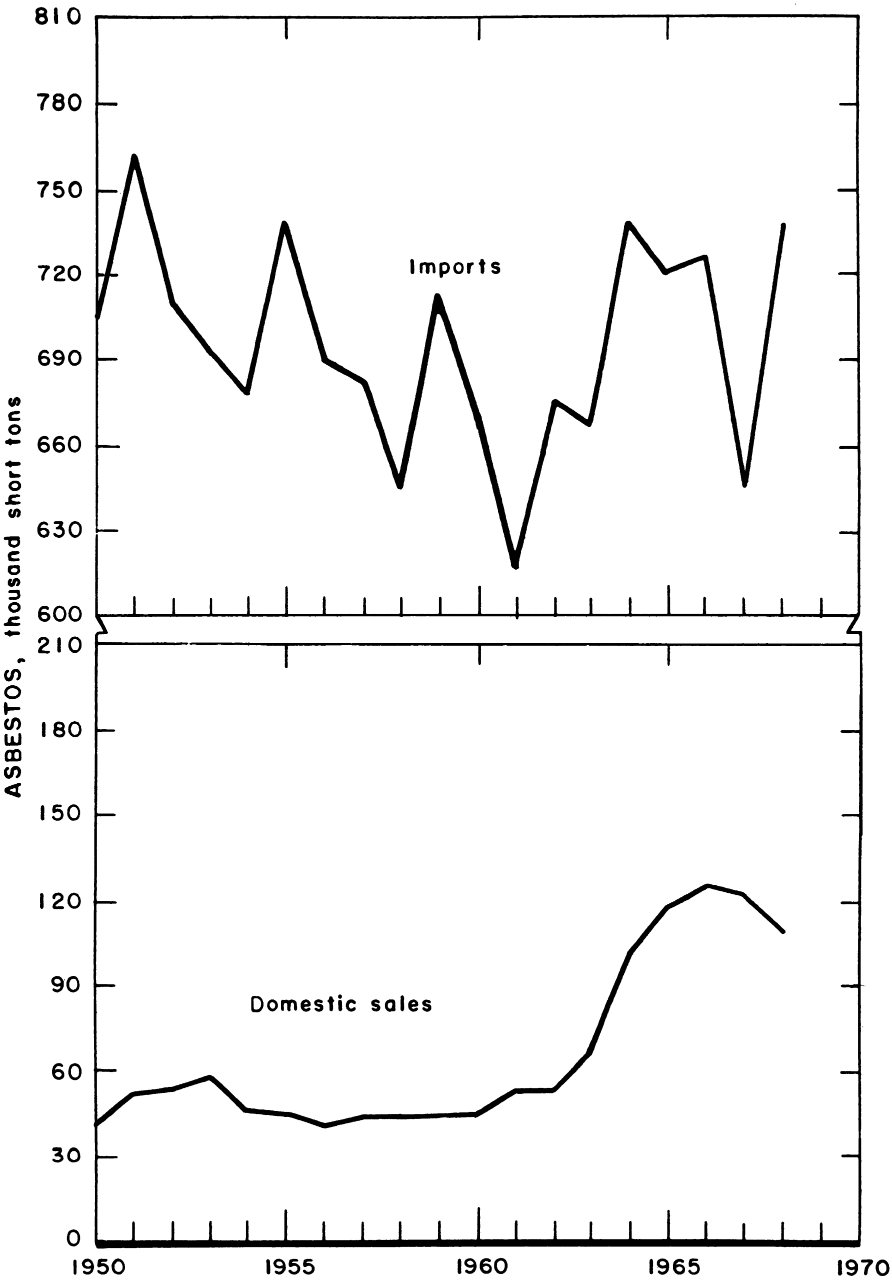

Figure 1.—United States production (sales) and imports of asbestos.

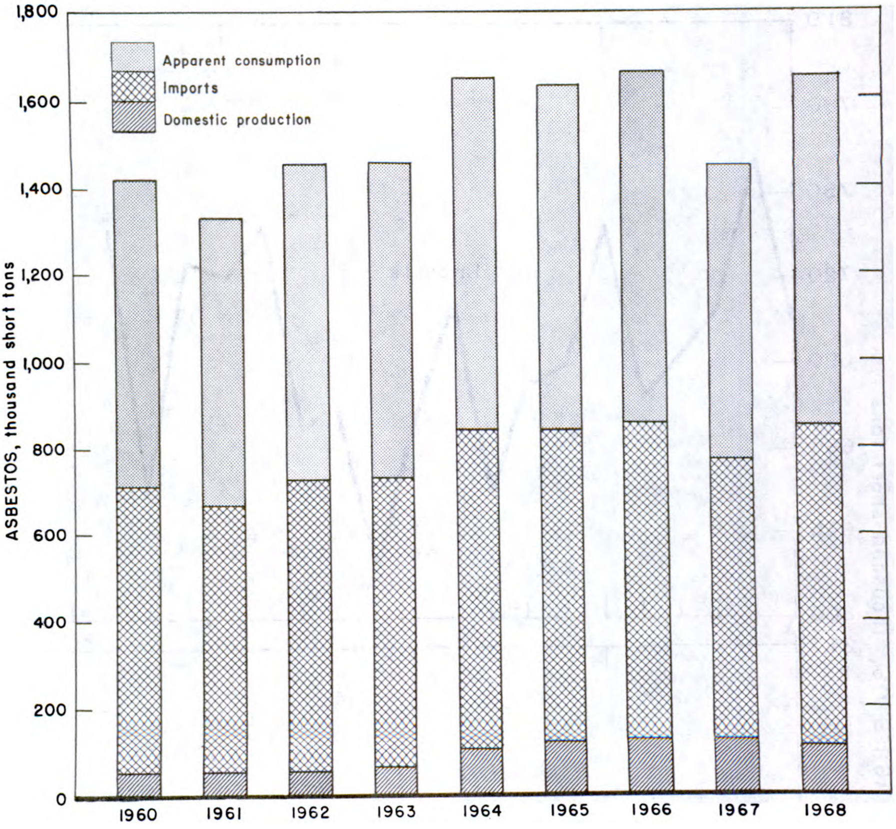

Figure 2.—Domestic supply and consumption of asbestos.

PRICES[3]

Prices for Vermont, Arizona, and Quebec asbestos increased in mid-1968 from 2 to 5 percent on the high-volume grades. No increase was posted, however, for British Columbia asbestos. Prices for California chrysotile and North Carolina anthophyllite were not published.

Quotations for Canadian (Quebec) chrysolite f.o.b. mine, were as follows:

Grade	Description	Per short ton	
		Mar. 31, 1968	Apr. 1, 1968
Group No. 1	Crude	Can$1,410	Can$1,410
Group No. 2	do	760	760
Group No. 3	Spinning fiber	360–588	367–600
Group No. 4	Shingle fiber	198–335	201–341
Group No. 5	Paper fiber	140–165	143–169
Group No. 6	Waste, stucco	101	104
Group No. 7	Refuse or shorts	47– 85	45– 87

---

[3] Asbestos. V. 50, No. 5, November 1968, p. 50.

Prices for British Columbia, Canada, chrysolite asbestos, f.o.b. Vancouver, were as follows, as of January 1, 1968:

Grade	Description	Per short ton
AAA	Nonferrous spinning fiber	Can$810
AA	do	643
A	do	484
AC	Asbestos cement fiber	345
AK	Shingle fiber	241
CP	do	220
AS	do	200
CT	do	195
AX	do	177
CY	do	126
AY	do	126

Prices for Arizona chrysotile asbestos were increased on August 1, 1968, the first price increase since July 10, 1964. Quotations, f.o.b. Globe, were listed as follows:

Grade	Description	Per short ton	
		July 31, 1968	Aug. 1, 1968
Group No. 1	Crude	$1410–1650	$1410–1650
Group No. 2	do	610– 900	700– 950
AAA		800	800
Group No. 3	Nonferrous filtering and spinning	425– 750	425– 700
Group No. 4	Nonferrous plastic and filtering	385– 500	400– 500
Group No. 5	Plastic and filtering	250– 400	385– 425
Group No. 6	Refuse or shorts	----------	250
Group No. 7	do	58– 90	65– 90

Prices for Vermont chrysotile asbestos, f.o.b. Morrisville, were as follows:

Grade	Description	Per short ton	
		July 31, 1968	Aug. 1, 1968
Group No. 3	Spinning and filtering	$319–342	$319–342
Group No. 4	Shingle fiber	183–296	186–296
Group No. 5	Paper fiber	129–153	132–156
Group No. 6	Waste, stucco or plaster fiber	93	96
Group No. 7	Shorts and floats	40.50– 75	44.50– 80
Group No. 8	Shorts	----------	26.50

Market quotations were unavailable for African and Australian asbestos because sales were negotiated privately. The following values were calculated from U.S. Department of Commerce import data:

Imports	Per short ton	
	1967	1968
Amosite: South Africa, Republic of	$152	$149
Chrysotile:		
Rhodesia, Southern	160	184
South Africa, Republic of	187	194
Crocidolite: South Africa, Republic of	191	193

FOREIGN TRADE

U.S. exports of manufactured asbestos products in 1968 increased 3 percent over those in 1967. Canada, West Germany, and Venezuela accounted for 36, 9, and 4 percent, respectively. Of reexports, Canada and the United Kingdom received 74 and 26 percent, respectively.

In 1968 total imports for consumption of asbestos were 14 percent greater than those in 1967. Imports of amosite from the Republic of South Africa increased 63 percent, while crocidolite from the same source decreased 6 percent. Low-iron, spinning-length, chrysotile imports from British Columbia decreased to 6,086 tons from 6,252 tons in 1967, and imports of all grades from this source decreased 14 percent.

Although embargoed by Presidential order, dated Jan. 5, 1967, declining quantities of asbestos continued to be received from Southern Rhodesia. This material probably was entered from bonded warehouses or shipped from stocks in other countries which were exported from Southern Rhodesia prior to December 1966.

Table 3.—U.S. exports and reexports of asbestos and asbestos products

Product	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
EXPORTS				
Unmanufactured:				
Crude and spinning fibers short tons	860	$238	872	$193
Nonspinning fibers do	26,603	4,021	17,066	2,308
Waste and refuse do	19,893	1,692	23,279	2,176
Total do	47,356	5,951	41,217	4,677
Products:				
Gaskets and packing do	2,326	5,253	2,415	5,895
Brake linings do	4,249	5,819	4,374	5,724
Clutch facings, including linings number	2,765,868	2,328	3,436,934	2,318
Textiles and yarn short tons	2,215	1,790	3,450	1,802
Shingles and clapboard do	10,729	1,996	10,651	1,944
Articles of asbestos cement do	11,020	2,159	5,896	1,628
Manufactures, n.e.c	NA	4,358	NA	5,193
Total	-----------	23,703	-----------	24,504
REEXPORTS				
Unmanufactured:				
Crude and spinning fibers short tons	256	52	-----------	--------
Nonspinning fibers do	106	22	19	2
Total do	362	74	19	2
Products:				
Gaskets and packing do	-----------	--------	3	1
Brake linings do	(1)	1	(1)	1
Clutch facings, including linings number	6,800	5	-----------	--------
Shingles and clapboard short tons	85	16	47	9
Articles of asbestos cement do	-----------	--------	42	3
Manufactures, n.e.c	NA	42	NA	9
Total	-----------	64	-----------	23

NA Not available.

[1] Less than ½ unit.

Table 4.—U.S. imports for consumption of asbestos (unmanufactured), by classes and countries

Year and country	Crude (including blue fiber)		Textile fiber		All other		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967								
Bolivia	-------	-------	-------	-------	3	$3	3	$3
Canada	6,966	$1,246	15,063	$5,745	579,953	52,174	601,982	59,165
Finland	662	26	-------	-------	2,585	166	3,247	192
France	15	2	-------	-------	-------	-------	15	2
Italy	1	1	-------	-------	6	7	7	8
Mozambique	250	32	-------	-------	-------	-------	250	32
Portugal	-------	-------	-------	-------	59	6	59	6
Rhodesia, Southern	420	68	75	26	4,956	775	5,451	869
South Africa, Republic of	29,318	5,081	17	3	1,280	255	30,615	5,339
Yugoslavia	-------	-------	827	30	2,656	97	3,483	127
Total	37,632	6,456	15,982	5,804	591,498	53,483	645,112	65,743
1968								
Bolivia	1	2	-------	-------	3	3	4	5
Canada	57	32	15,318	5,869	674,008	59,450	689,388	65,351
Cyprus	16	3	-------	-------	-------	-------	16	3
Finland	578	32	110	6	3,774	219	4,462	257
France	-------	-------	-------	-------	30	4	30	4
Italy	2	1	-------	-------	3	3	5	4
Mozambique	150	20	-------	-------	742	165	892	185
Panama	-------	-------	-------	-------	54	3	54	3
Portugal	-------	-------	-------	-------	24	2	24	2
Rhodesia, Southern	85	16	-------	-------	2,734	504	2,819	520
South Africa, Republic of	37,249	6,260	5	1	1,233	274	38,487	6,535
Southern Africa, n.e.c	80	16	-------	-------	-------	-------	80	16
Yugoslavia	-------	-------	1,653	45	-------	-------	1,653	45
Total	38,218	6,382	17,086	5,921	682,605	60,627	737,909	72,930

Table 5.—U.S. imports for consumption of asbestos from specified countries, by grades

(Short tons)

Grade	1967			1968		
	Canada	Southern Rhodesia	Republic of South Africa	Canada	Southern Rhodesia	Republic of South Africa
Chrysotile:						
Crudes	6,966	420	1,843	57	85	2,817
Spinning and textile	15,063	75	17	15,318	---------	5
All other	579,953	4,956	1,280	674,008	2,734	1,233
Crocidolite (blue)	---------	---------	14,917	---------	---------	13,965
Amosite	---------	---------	12,558	---------	---------	20,467
Total	601,982	5,451	30,615	689,383	2,819	38,487

WORLD REVIEW

Australia.—Production of chrysotile asbestos in 1968 was 895 tons, up 22 percent from the 734 tons of 1967. Imports in 1967 included 39,752 tons of chrysotile, almost wholly from Canada, and 10,345 tons of amosite, 96 percent from Republic of South Africa. Total imports equaled 52,584 tons.

Canada.—Production as measured by sales rebounded from the setback in 1967, increasing 10 percent to 1,596,011 tons in 1968. Exports increased 9 percent to 1,459,650, with a rise in value of almost 12 percent to Can$192,895,000.

The Asbestos Corporation Ltd. began sinking a 1,645-foot exploration shaft into the Penhale ore body on the company's Vimy Ridge property, 5 miles southwest of Thetford Mines, Quebec. This $2.5 million project is to confirm drill-indicated reserves in a program due for completion in late 1971.[4] A drift will also be driven laterally into the ore body at the 1,120-foot level. If results warrant it, the shaft and the drift will be incorporated into a new underground mine, estimated to cost an additional $5.25 million to bring into production. If the plans are realized, the mine will be the largest underground asbestos mine in the world, with a production capacity of 8,200 tons per day.

---

[4] Mining in Canada (Winnipeg). January 1969, p. 35.

Table 6.—World production of asbestos, by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada (sales)	1,419,851	1,388,212	[r] 1,489,055	1,452,104	1,596,011
United States (sold or used by producers)	101,092	118,275	125,928	123,189	120,690
South America:					
Argentina	542	243	53	[p] 201	NA
Brazil [2]	• 1,430	1,204	1,820	1,393	NA
Europe:					
Bulgaria	1,433	1,433	• 1,430	• 1,984	• 1,984
Finland [3]	11,611	13,307	13,250	11,601	• 13,228
France	24,289	11,179	331	165	-----------
Italy	[r] 75,570	[r] 79,287	[r] 90,748	111,402	• 116,845
Portugal	-----------	53	11	57	• 28
U.S.S.R.	810,000	[r] • 821,221	[r] • 832,244	• 847,676	881,848
Yugoslavia	9,280	10,585	8,411	9,944	[e] 11,028
Africa:					
Botswana	2,161	888	-----------	-----------	-----------
Kenya	204	136	73	56	NA
Mozambique	-----------	[r] 88	535	559	NA
Rhodesia, Southern	153,450	176,149	• 176,370	NA	NA
South Africa, Republic of	215,592	240,752	276,597	268,482	260,530
Swaziland	39,862	40,884	36,142	40,154	42,946
United Arab Republic	1,739	3,225	[4] 2,057	NA	NA
Asia:					
China, mainland [e]	130,000	140,000	150,000	165,000	165,000
Cyprus	13,755	17,622	24,449	19,447	• 23,038
India	3,710	5,264	7,646	8,095	NA
Japan	17,979	16,451	21,428	27,037	• 27,558
Korea, South	1,402	1,710	687	2,388	3,650
Philippines	586	-----------	551	64	NA
Taiwan	526	883	721	631	1,323
Turkey	1,291	1,376	[r] 1,258	2,421	3,183
Oceania: Australia	13,545	11,567	13,467	734	895
Total [5]	[r] 3,050,900	[r] 3,101,994	[r] 3,275,262	[r] 3,094,784	NA

• Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Negligible quantities also produced in Bolivia, Czechoslovakia, Eritrea, Malagasy Republic, North Korea, and Rumania.

[2] Bahia only.

[3] Includes asbestos flour.

[4] Includes vermiculite.

[5] Total is of listed figures only.

Table 7.—Canada: Shipments[1] of asbestos, by grades

(Short tons)

Grade	1964	1965	1966	1967	1968
Quebec, milled group:					
3 (spinning)[2]	31,594	21,356	28,716	25,391	32,248
4 (shingle)	319,629	322,772	371,837	336,568	335,807
5 (paper)	188,672	168,759	190,278	185,450	193,446
6 (stucco)	232,382	208,682	229,426	244,021	255,648
7 (refuse)	507,003	506,497	512,030	490,087	542,124
8 (sand)	5,602	6,088	8,706	7,149	3,037
Newfoundland, Ontario, and British Columbia	135,887	153,401	138,288	154,345	147,389
Total [3]	1,420,769	1,387,555	1,479,281	1,443,011	1,509,699

[1] Includes tonnage for own use.

[2] Includes crude No. 1, 2, and other.

[3] Data may not add to totals shown because of independent rounding.

Source: Dominion Bureau of Statistics.

The highly mechanized operation would use rubber-tired, diesel-powered, load-haul-dump vehicles to take ore to an underground crusher. A load-haul-dump unit is now on trial at one of the company's existing underground mines.[5]

The Asbestos Corporation Ltd. announced that construction has commenced at the King-Beaver mine on a new ore preparation plant costing $2.5 million.[6] This new facility, scheduled for operation by September 1, 1969, will process all King-Beaver's open-pit ore. Concurrently, a new underground crushing station at the King-Beaver No. 3 shaft was being built to handle all the ore from underground operations and is expected to be completed in May 1969. This will consolidate the two separate underground operations, and all ore will be hoisted through No. 3 shaft.

The corporation also announced that reserves at yearend were as follows:[7]

	Thousand short tons
King-Beaver mine	44,655
British Canadian mine	68,285
Normandie mine	11,622
Asbestos Hill	18,738
Other properties	10,611
Total	153,911

During 1968 Hedman Mines Ltd. continued construction on its new mill near Matheson, Ontario.[8] The mill will have an ore-crushing capacity of 600 tons per day and an initial fiberizing capacity of 300 tons per day. Stripping operations begun in 1967 have exposed enough ore in the initial pit to last 4 years. Meanwhile, the company continued pilot plant tests in which fiber output was up to 500 tons per month.

During 1968 the Cassiar Asbestos Corporation Ltd.'s Clinton mine in the Yukon Territory commenced operation. Shipments for the year totaled 53,749 tons, with the United States, the United Kingdom, and Australia as the principal recipients.

Greece.—The Hellenic Industrial Development Bank (HIDB) planned to reopen the asbestos mine at Zidani Kozanis in northeastern Greece, where recent prospecting has shown the existence of 15 million tons of chrysotile-bearing ore.[9] HIDB plans an open-pit mine and mill at Kozani with the capacity to produce 600,000 tons of ore annually. The target for production of finished fiber has been set at 25,000 tons.

Italy.—Italy's only asbestos producer, the Balangero mine near Turin, has been expanded and modernized at a cost of 400 million lire.[10] The mine, operated by Societá Amiantifera di Balangero of Milan, is now fully mechanized; excavation of the serpentine ore and primary crushing are done in a mobile plant capable of handling 500 short tons per hour. Throughput of ore could be as high as 2.2 million tons and it will enable Amiantifera di Balangero, which markets short fiber chrysotile asbestos, to maintain output at about 100,000 tons of fiber per year. The company, a successor to Anonima Cave di San Vittore set up in 1918, is capitalized at 600 million lire and is associated with Eternit SpA, a major manufacturer of asbestos cement products. About one-third of the production in recent years has been exported. Reserves of ore at the open-pit mine, which employs 280, are estimated to be 70 million tons.

South Africa, Republic of.—Asbestos production totaled 260,530 tons, a decrease of 7,952 tons, or 3 percent from that of 1967. Amosite production rose 2 percent, chrysotile rose about 16 percent, and crocidolite dropped 10 percent. Exports totaled 262,158 tons valued at 28,727,376 rands.

Swaziland.—Chrysotile asbestos production from the Havelock mine, Swaziland's sole producer, increased 7 percent over that of 1967. The King of Swaziland granted prospecting rights to the London-Rhodesian Mining and Land Co. Ltd. in an area adjacent to the Havelock property, which may lead to the opening of a second mine.[11]

U.S.S.R.—Total production of six grades of asbestos in 1968 was estimated at 881,848 short tons. Asbestos exports rose from 283,070 tons in 1966 to 314,380 in 1967. Data released by the All-Union Building

---

[5] Work cited in footnote 4.

[6] Asbestos Corporation Ltd. Annual Report. Montreal, 1968, p. 3.

[7] Work cited in footnote 6.

[8] Mining Journal (London). V. 270, No. 6925, May 10, 1968, p. 383.

[9] Industrial Minerals (London). No. 14, November 1968, p. 31.

[10] Industrial Minerals (London). No. 8, May 1968, p. 24.

[11] Mining & Engineering Journal (Johannesburg). V. 79, No. 3952, Pt. 2, Nov. 1, 1968, p. 1031.

Material Institute indicated that about 50 percent of the mine waste was used in aggregates, and the rest was relegated to dumps.

In 1967 and 1968 East European countries increased their imports from Canada which prompted the Soviet journal Foreign Trade to charge the Canadian industry with price manipulation and with the granting of confidential discounts on the listed prices in signing long-term contracts.[12]

TECHNOLOGY

Technological advances in 1968 related more to new products and applications than to developments in mining and milling. Union Carbide Corp. developed a process for shearing asbestos to obtain a high degree of fiber separation.[13] The product is then pelletized to provide an improved material for use in drilling muds.

Improved characteristics of thermoplastics resulted from the use of asbestos additives.[14] It was reported that such additions increase strength, rigidity, gloss and heat stability of various plastic products.

Medical research on the effects of asbestos on human health continued during 1968.

In October, the Nation's first cooperative effort by labor, industry, science, and Government to conduct a health research program for industrial workers was inaugurated at Mount Sinai School of Medicine, City University of New York.[15] Dr. Irving J. Selikoff, Director of Mount Sinai's Environmental Sciences Laboratory, will direct the new activity, known as the Insulation Industry Hygiene Research Program. This research, budgeted at $362,500 for the first year, was financed jointly by Johns-Manville and the International Association of Heat and Frost Insulators and Asbestos Workers. Its primary purpose is to develop improved methods of minimizing exposure of insulation workers to dust and fumes encountered in their work. The Bureau of Occupational Safety and Health, U.S. Public Health Service, will provide consultation and technical assistance.

---

[12] Mining Journal (London). V. 270, No. 6948, Oct. 18, 1968, p. 295.

[13] Kennedy, John L. Preshearing, Pelletizing Improves Asbestos Fibers for Drilling Mud. Oil and Gas J., v. 66, No. 44, Oct. 28, 1968, pp. 102–103.

[14] Product Engineering. V. 39, No. 22, Oct. 21, 1968, p. 120.
Steel. V. 162, No. 13, Mar. 25, 1968, p. 138n.

[15] Johns-Manville Corporation. Annual Report. New York, 1968, p. 5.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/5

Barite

By W. Gene Diamond[1]

Barite, sold or used in the United States in 1968, totaled 927,000 short tons, down 3.6 percent from 1967. Total U.S. value increased, however, because the valuation of barite was changed to reflect prices following ore treatment; the value for three States increased substantially because the new prices reflected the value of a finished mill product. Primary barite imports for consumption in 1968 increased 25 percent to 663,000 tons.

DOMESTIC PRODUCTION

Barite was mined by open-pit and underground methods in eight States in 1968; Arkansas, Georgia, Missouri, and Nevada accounted for nearly 87 percent of the total output. Missouri ranked first and Nevada replaced Arkansas as the second largest producer.

Ground and crushed barite was produced in nine States; output was slightly greater than in 1967. Milchem, Inc., completed construction of a barite mill in Lander County, Nev., to treat ore from a mine 8 miles from the mill. Output from the plant was shipped to California.[2]

---

[1] Supervisory statistician, Bartlesville Office of Mineral Resources.

[2] Engineering and Mining Journal. V. 169, No. 12, December 1968, p. 120.

Table 1.—Salient barite and barium-chemical statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Barite (primary):					
Mine or plant production	817	846	1,007	944	NA
Sold or used by producers	830	852	947	962	[1] 927
Value	$9,796	$10,192	$11,259	$11,604	[1] $13,706
Imports for consumption	600	712	699	532	663
Value	$4,796	$5,553	$5,764	$4,655	$5,666
Consumption [2]	1,277	1,388	1,417	1,371	NA
Ground and crushed sold by producers	1,077	1,169	1,209	r 1,144	1,266
Value	$26,948	$29,444	$30,641	r $28,754	$30,563
Barium chemicals sold by producers	117	125	133	113	136
Value	$17,101	$17,935	$19,109	$16,283	$18,811
World: Production	3,488	3,899	4,068	3,820	3,915

r Revised. NA Not available.
[1] Data not comparable to previous years.
[2] Includes some witherite.

Table 2.—Barite (primary) sold or used by producers in the United States by States

(Thousand short tons and thousand dollars)

State	1967		1968 [1]	
	Quantity	Value	Quantity	Value
Alaska	W	W	91	W
Arkansas	229	$2,266	166	$3,889
California	10	71	W	W
Georgia	W	W	140	2,874
Missouri	332	4,444	284	4,102
Nevada	154	923	216	1,511
North Carolina	1	6	W	W
Tennessee	15	235	21	362
Washington	(2)	1	----	------
Undistributed	221	3,658	8	1,019
Total [3]	962	11,604	927	13,706

W Withheld to avoid disclosing individual company confidential data.

[1] 1968 includes 222,828 short tons chemical grade valued at $4,250,142 and 703,892 short tons drilling grade valued at $9,455,166.

[2] Less than ½ unit.

[3] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Barite was used mainly as a weighting agent in oil- and gas-well drilling muds. The relatively high specific gravity of barite provides additional weight to the drilling muds that restrain high oil and gas pressures and helps prevent caving and blowouts. Substantial quantities of chemical grade barite were used in glass, paint, and rubber manufacturing and in compounds such as barium carbonate for making glass and ceramic glazes and enamels; barium chloride for case hardening, producing magnesium metal, and water treatment; and barium hydroxide for ceramics, lubricating oils, and sugar refining.

Producers of ground and crushed barite from domestic and foreign sources in 1968 reported increased quantities of barite utilized for chemicals, well drilling, paint, and rubber industries; the only decreased usage was noted in the glass industry.

Major producers of barium chemicals from barite included the following: J. T. Baker Chemical Co., Phillipsburg, N.J.;

Table 3.—Ground and crushed barite sold by producers [1]

Use [2]	1966		1967		1968	
	Short tons	Percent of total	Short tons	Percent of total	Short tons	Percent of total
Barium chemicals [3]	202,889	14	170,096	13	175,830	13
Well drilling	1,022,106	[r] 73	[r] 964,982	[r] 73	1,006,418	73
Glass	73,660	[r] 5	76,220	[r] 6	71,770	5
Paint	69,895	[r] 5	59,698	5	60,894	4
Rubber	38,249	3	31,039	[r] 2	41,639	3
Other	4,605	-----	[r] 12,964	[r] 1	20,907	2
Total	[r] 1,410,904	100	[r] 1,314,999	100	1,377,458	100

[r] Revised.

[1] Includes imported barite.

[2] Uses reported by the producers of ground and crushed barite, except for barium chemicals.

[3] Quantities reported by consumers.

Chemical Products Corp., Cartersville, Ga.; Chicago Copper & Chemical Co., Blue Island, Ill.; Chemetron Corp., Huntington, W. Va.; The Great Western Sugar Co., Johnstown, Colo.; Inorganic Chemicals Division, FMC Corp., Modesto, Calif.; Mallinckrodt Chemical Works, St. Louis, Mo.; Ozark Smelting and Mining Co., Coffeyville, Kans.; Pittsburgh Plate Glass Co., Chemical Division, New Martinsville, W. Va.; and Sherwin Williams Co., Ashtabula, Ohio.

Other companies which gave additional processing to barium chemicals included the following: Barium Chemicals, Inc., Steubenville, Ohio; Eastman Kodak Co., Rochester, N.Y.; The Glidden Co., Baltimore, Md.; and Inorganic Chemicals Division, FMC Corp., Carteret, N.J.

Table 4.—Barium chemicals produced and used or sold by producers[1] in the United States in 1968

Chemical	Plants	Produced (short tons)	Sold or used by producers	
			Short tons	Value (thousands)
Barium carbonate	7	82,855	80,315	$8,281
Other barium chemicals[2]	([3])	53,838	55,279	10,530
Total[4]	9	136,693	135,594	18,811

[1] Only data reported by barium chemical producers that consume barite (primary) are included.

[2] Includes black ash, blanc fixé, barium acetate, chloride, hydrate, nitrate, oxide, peroxide, sulfate and other compounds for which separate data may not be revealed.

[3] Black ash and lithopone, 2 plants; acetate, 1; chloride, 3; hydroxide, 3; nitrate, 1; oxide, 1; peroxide, 1; sulfate, 2.

[4] A plant producing more than 1 product is counted only once in arriving at total.

PRICES

Prices of crude and ground barite, as published in trade journals, serve as a general guide and do not necessarily reflect actual transactions. Prices generally are negotiated between the buyer and seller.

The quoted price of chemical grade barite produced by flotation or magnetic separation increased from $24.50 per short ton to $25 in June and to $26.50 in September.

Table 5.—Price quotations for crude and ground barite in 1968

(Per short ton)

Item	1968
Chemical grade, f.o.b. shipping point, carlots:	
Hand picked, 95 percent $BaSO_4$, 1 percent Fe	$20.00 to $20.50
Flotation or magnetic separation; 96–97.5 percent $BaSO_4$, 0.3–0.7 percent Fe (add $3 for 100-pound bags)	24.50 to 26.50
Water ground; 99.5 percent $BaSO_4$, 325 mesh, 50-pound bags	45.00 to 49.00
Drilling-mud grade, f.o.b. shipping point, carlots:	
83–93 percent $BaSO_4$, 3–12 percent Fe, specific gravity 4.20–4.30:	
Crude, bulk	12.00 to 16.00
Some restricted sales	11.50
Ground	23.00 to 26.00
Imported crude, bulk, c.i.f. gulf ports	10.00 to 14.00

Source: Engineering and Mining Journal.

FOREIGN TRADE

Exports of lithopone (a mixture of zinc sulfide and barium sulfate used as paint pigment) increased in 1968 compared with 1967 exports but were considerably lower than in 1966. Principal countries receiving lithopone were Canada, South Vietnam, Venezuela, the Philippines, Brazil, and Honduras.

Imports of crude barite for consumption in 1968 totaled 663,000 short tons, up 25 percent from 1967 imports. The increase in imports with a decrease in domestic tonnage sold or used reflects the competition of foreign barite in the drilling-mud market. The imported barite entered the United States through the following cities: New Orleans, La.—49.1 percent; Laredo, Tex.—21.5 percent; Port Arthur, Tex.—17.5 percent; Houston, Tex.—5.0 percent; Galveston, Tex.—2.9 percent; and El Paso, Tex., Cleveland, Ohio, and San Diego, Calif.—4.0 percent.

Table 6.—U.S. exports of lithopone

Year	Short tons	Value (thousands)
1966	3,017	$644
1967	735	267
1968	1,300	281

Table 7.—U.S. imports for consumption of barite, by countries

(Thousand short tons and thousand dollars)

Type and source	1967		1968	
	Quantity	Value	Quantity	Value
Crude barite:				
Algeria	17	$163	17	$190
Canada	134	1,141	104	911
Germany, West	(1)	1	-----	-----
Greece	37	306	75	622
Ireland	58	437	144	1,094
Italy	8	99	22	275
Mexico	133	1,055	131	839
Morocco	49	497	56	587
Panama	-----	-----	8	106
Peru	71	729	94	937
Turkey	25	227	12	105
Total	532	4,655	663	5,666
Ground barite:				
Canada	(1)	2	-----	-----
France	(1)	2	-----	-----
Total	(1)	4	-----	-----

[1] Less than ½ unit.

Table 8.—U.S. imports for consumption of barium chemicals

Year	Lithopone		Blanc fixé (precipitated barium sulfate)		Barium chloride		Barium hydroxide	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	182	$33	2,705	$304	1,287	$128	11	$2
1967	116	22	2,249	282	979	120	-------	-------
1968	246	37	2,783	397	1,413	149	-------	-------

Year	Barium nitrate		Barium carbonate, precipitated		Other barium compounds	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	1,005	$170	1,150	$74	444	$249
1967	1,046	153	813	54	156	73
1968	710	103	656	43	415	151

Table 9.—U.S. imports for consumption of crude, unground, and crushed or ground witherite

Year	Crude, unground		Crushed or ground	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	2,133	$100	90	$8
1967	1,260	53	25	3
1968	2,029	59	25	17

WORLD REVIEW

Australia.—South Australian Barytes, Ltd., more than tripled mill production, which totaled 14,638 tons for the last 6 months of 1968, compared with the last 6 months of 1967. The increases were responsive to increased Australian offshore drilling activity.[3]

Belgium.—Belgian authorities granted Mines de Garrot the right to operate an idle mine at Fleurus, near Charleroi, following development of an estimated 600,000 tons of barite reserves. Before World War I, the Fleurus mine supplied large quantities of crushed barite for lithopone production.[4]

---

[3] Mining Journal (London). V. 272, No. 6968, Jan. 31, 1969, p. 99.

[4] Industrial Minerals (London). No. 14, November 1968, p. 30.

Table 10.—World production of barite, by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada	169,149	203,025	221,876	172,270	137,699
Mexico	368,220	406,027	321,306	246,124	271,762
United States	816,700	845,650	[r] 1,006,959	944,081	[2] 926,729
South America:					
Argentina	15,989	21,843	[r] 19,827	[p] 19,842	[e] 19,842
Brazil	36,968	70,945	44,344	60,073	47,472
Chile	1,203	3,132	2,345	4,965	4,394
Colombia	11,244	9,700	[r] 8,157	6,622	8,344
Peru	138,252	122,104	128,579	[p] 121,254	121,254
Europe:					
Austria (marketable)	1,390	2,573	3,086	2,675	1,610
Czechoslovakia [e]	5,512	5,512	5,512	5,512	5,512
France	92,397	114,733	[r] 109,262	112,435	110,231
Germany:					
East [e]	33,069	33,069	33,069	33,069	33,069
West (marketable)	515,290	517,374	497,418	451,569	502,561
Greece	74,957	132,277	[r] 143,300	165,347	[e] 165,347
Ireland	45,232	92,581	137,789	83,776	157,630
Italy	[r] 113,422	[r] 157,649	[r] 175,104	169,828	224,849
Poland [e]	50,376	50,376	51,809	51,809	51,809
Portugal	384	[r] 3,646	[r] 1,120	348	176
Rumania	NA	49,604	[e] 55,116	[e] 60,627	[e] 60,627
Spain	65,188	61,140	[e] 60,627	[e] 44,092	[e] 55,116
U.S.S.R. [e]	242,508	253,531	275,578	286,601	286,601
United Kingdom [3]	68,343	67,241	34,172	40,785	44,092
Yugoslavia	112,072	107,045	88,898	93,121	[e] 94,799
Africa:					
Algeria	32,665	[r] 28,230	[r] 29,884	34,557	35,274
Kenya	----------	40	108	234	386
Morocco	99,036	114,508	117,126	99,779	NA
Rhodesia, Southern	1,561	[e] 1,543	[e] 2,205	[e] 2,205	[e] 2,205
South Africa, Republic of	2,835	1,477	6,815	1,646	631
Swaziland	17	541	1,150	623	1,079
United Arab Republic	5,017	16,924	[r] 7,495	1,413	411
Asia:					
Burma	NA	1,940	[e] 8,818	10,362	11,111
China, mainland [e]	110,231	110,231	121,254	110,231	132,000
India	[r] 52,035	53,223	56,949	56,997	57,009
Iran [e]	[r] 47,399	[r] 68,894	92,925	99,208	104,719
Japan	43,810	46,606	44,396	41,417	61,078
Korea:					
North [e]	77,162	88,185	110,231	121,254	121,254
South	3,024	1,419	40	----------	6
Pakistan	13,235	[r] 7,937	8,624	[e] 11,023	[e] 16,535
Philippines	1,627	----------	2	NA	NA
Thailand	NA	NA	NA	246	248
Turkey	6,669	13,206	[r] 20,591	34,822	22,369
Oceania: Australia	13,778	13,418	15,370	17,545	17,637
Total [4]	[r] 3,487,961	[r] 3,899,094	[r] 4,068,231	[r] 3,820,387	3,915,477

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Barite is also produced in Bulgaria, but data on production are not available.

[2] Sold or used by producers.

[3] Includes witherite.

[4] Total is of listed figures only.

Canada.—Canadian barite production decreased in 1968 as a result of a fire which destroyed a large part of the barite plant at Walton, Nova Scotia. The mine and plant, operated by Dresser Minerals Division of Dresser Industries, Inc., has in recent years yielded approximately 85 percent of the barite produced in Canada. During plant reconstruction, the company deepened the shaft at the mine from 1,370 feet to 1,670 feet. Production of barite by two companies in British Columbia supplied the oil- and gas-well drilling industry in western Canada.[5]

India.—A 24,000-ton-per-year barite grinding mill began operation at Batamandi, near Yamunanagar, in Himachal Pradesh. Locally mined barite will be ground in the plant.[6]

Geophysical surveys for barite at Phutana, Chanda District, Maharashtra State, were undertaken by National Geophysical Research Institute (NGRI) at the request of the Government. The geophysical work indicated that the deposit is not in the form of continuous veins.[7]

Iran.—Sogémiran, S.A., produced lead and barite concentrates at the new 500-ton-per-day Ravanje flotation mill. The mine and mill are near Dalijan, 150 miles southwest of Teheran. The barite was used locally in drilling muds.[8]

Liberia.—An exclusive long-term concession to explore for barite on a 185,000-acre tract was awarded to Dresser Industries, Inc., by the Liberian Government. Dresser also was granted the right to operate mines on selected acreage from the tract. Under terms of the agreement, the company has a 30-year mining concession including a minimum 2-year exploration period beginning within 6 months. Dresser will pay a royalty on all barite removed from the concession.[9]

Pakistan.—Ground barite was produced by Crown Mining Corp.; Industrial Grinding Ltd., a subsidiary of International Combustion, Ltd.; and United Grinding Ltd. The Crown Mining Corp. mined barite at Lasbela, 100 miles from Karachi, and moved the material by truck to its mill at Karachi. Industrial Grinding, Ltd., purchased crude barite for grinding. United Grinding, Ltd., mined and purchased barite.[10]

Thailand.—A $1 million joint venture of International Minerals & Chemical Corp. and Mae Huey Yai Mining Co. was organized to operate a barite mine and mill in Songkhla Province. Later plans of the venture include mining in Yala Province.[11]

TECHNOLOGY

Under a cooperative agreement between the Bureau of Mines and the Division of Geological Survey and Water Resources of Missouri, research to determine the recoverable barite remaining in barite-ore-washer waste ponds was started. Results will be evaluated and reported by the Missouri Geological Survey.

---

[5] Canadian Mining Journal. V. 90, No. 2, February 1969, p. 124.

[6] Industrial Minerals (London). No. 14, November 1968, p. 32.

[7] Journal of Mines, Metals, and Fuels (Calcutta, India). V. 16, No. 8, August 1968, p. 317.

[8] World Mining. V. 4, No. 13, December 1968, p. 59.

[9] Mining Congress Journal. V. 54, No. 12, December 1968, p. 5.

[10] Bureau of Mines. Mineral Trade Notes. V. 66, No. 5, May 1969, p. 4.

[11] Engineering and Mining Journal. V. 170, No. 1, January 1969, p. 130.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/16

Bauxite

By John G. Parker [1]

In 1968 worldwide bauxite production remained about the same as that of 1967 but alumina plant capacity increased about 5 percent, with much of the increase being in plants in Asia and Australia. Imports of alumina for aluminum production rose nearly 40 percent to 1.3 million short tons.

Legislation and Government Programs.—Only 916 long tons of calcined, refractory-grade bauxite was sold from the national stockpile during 1968.

Of a sales offering by General Services Administration of 1,000 short dry tons of fused crude aluminum oxide, only 100 tons was sold to a Massachusetts abrasive company.

Table 1.—Salient bauxite statistics

(Thousand long tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Production, crude ore (dry equivalent)	1,601	1,654	1,796	1,654	1,665
Value	$17,875	$18,632	$20,095	$19,079	$23,752
Exports (as shipped)	279	147	62	2	7
Imports for consumption [1]	10,180	11,199	11,529	11,594	10,976
Consumption (dry equivalent)	12,546	13,534	14,084	14,503	14,097
World: Production	32,833	36,849	40,041	43,889	42,880

[1] Includes bauxite imported for Government account. Import figures for Jamaican, Haitian, and Dominican Republic bauxite included were adjusted by Bureau of Mines to dry equivalent. Other imports, which are virtually all dried, are on an as-shipped basis.

DOMESTIC PRODUCTION

Output of crude bauxite (dry equivalent) increased only slightly over that of the previous year, with Arkansas, the major producing State, having 95 percent of the output total.

There were 12 domestic bauxite mines operated by eight firms in 1968, five in Saline County, Ark., three each in Barbour and Henry Counties, Ala., and one in Sumter County, Ga. The two largest producers, Reynolds Metals Co. and Aluminum Company of America (Alcoa), shipped crude ore from Arkansas to their own alumina plants. The Saline County mine of American Cyanamid Co. continued to supply the firm's calcined bauxite plant at Benton, Ark. In Pulaski County, Ark., Porocel Corp. and Stauffer Chemical Co. produced activated bauxite.

In Alabama, the following firms mined bauxite: Harbison-Walker Refractories Co., Eufaula Bauxite Mining Co. (the former R. E. Wilson Mining Co.), Wilson-Snead Mining Co., General Refractories Co., and A. P. Green Refractories Co. Harbison-Walker was the State's major producer of calcined bauxite, with a small output from A. P. Green. Eufaula was the only producer of dried bauxite. In Georgia, American Cyanamid mined and processed crude bauxite.

A total of 6.44 million short tons of aluminum oxide was produced in 1968, 6.05 million tons of the calcined variety, 324,000 tons of trihydrate alumina, and

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Mine production of bauxite and shipments from mines and processing plants to consumers in the United States

(Thousand long tons and thousand dollars)

State and year	Mine production			Shipments from mines and processing plants to consumers		
	Crude	Dry equivalent	Value [1]	As shipped	Dry equivalent	Value [1]
Alabama and Georgia:						
1964	51	39	$444	57	57	$809
1965	79	61	658	57	56	792
1966	102	78	656	85	82	1,108
1967	108	83	810	85	84	1,236
1968	110	83	694	74	69	898
Arkansas:						
1964	1,864	1,562	17,431	1,773	1,531	17,859
1965	1,911	1,593	17,974	2,008	1,729	20,293
1966	2,060	1,718	19,439	1,891	1,636	19,788
1967	1,943	1,571	18,269	2,022	1,742	21,343
1968	1,961	1,582	23,058	1,962	1,680	25,349
Total United States:						
1964	1,915	1,601	17,875	1,830	1,588	18,668
1965	1,990	1,654	18,632	2,065	1,785	21,085
1966	2,162	1,796	20,095	1,976	1,718	20,896
1967	2,051	1,654	19,079	2,107	1,826	22,579
1968	2,071	1,665	23,752	2,036	1,749	26,247

[1] Computed from selling prices and values assigned by producers and estimates of the Bureau of Mines.

Table 3.—Recovery of dried, calcined, and activated bauxite in the United States

(Long tons)

Year	Crude ore treated	Processed bauxite recovered [1]	
		Total	
		As recovered	Dry equivalent
1964	166,884	93,235	128,347
1965	193,076	99,765	140,713
1966	202,443	117,326	157,206
1967	223,174	123,200	166,696
1968	209,900	107,722	152,106

[1] Dried, calcined or activated bauxite.

the rest, tabular, activated and light hydrate.

Shipments of alumina and aluminum oxide products totaled 6.23 million tons of which 5.84 million tons went to the aluminum industry, with the rest shipped to the refractory, ceramic, chemical and abrasive industries.

In 1968, 60,080 short tons of alumina was shipped to the United States from the Virgin Islands. The St. Croix plant owned by Harvey Aluminum, Inc., and eight continental United States alumina plants owned by four aluminum firms are the source of the entire calcined alumina output.

Table 4.—Capacities of domestic alumina plants, December 31, 1968

(Thousand short tons per year)

Company and plant	Capacity
Aluminum Company of America:	
Mobile, Ala	950
Bauxite, Ark	400
Point Comfort, Tex	900
Total	2,250
Reynolds Metals Co.:	
Hurricane Creek plant, Bauxite, Ark	840
Sherwin plant, Corpus Christi, Tex	1,185
Total	2,025
Kaiser Aluminum & Chemical Corp.:	
Baton Rouge, La	1,042
Gramercy, La	720
Total	1,762
Ormet Corp.: Burnside, La	550
Harvey Aluminum, Inc.: St. Croix, Virgin Islands	350
Grand total	6,937

CONSUMPTION AND USES

Alumina production accounted for 93 percent of domestic bauxite consumption, of which 86 percent was imported material. In order of quantities used, the chemical, refractory, and abrasive industries consumed most of the remainder. Minor quantities of bauxite were used by the cement, oil and gas, and steel industries, and municipal water works.

The percent of domestic bauxite shipments, by various silica content ranges, are as follows:

SiO_2, percent	1964	1965	1966	1967	1968
Less than 8	6	5	10	4	15
8 to 15	63	64	60	73	53
More than 15	31	31	30	23	32

The aluminum industry received 94 percent of total alumina shipments. The chemical, refractory, ceramic, and abrasive industries received most of the rest.

Calcined alumina consumed by primary aluminum reduction plants totaled 6.00 million tons. The quantities of bauxite and alumina consumed to produce 1 ton of aluminum since 1964 were as follows:

	1964	1965	1966	1967	1968
Bauxite long dry tons	4.074	4.136	4.088	3.993	3.888
Alumina short tons	1.901	1.891	1.904	1.878	1.845
Aluminum short tons	1.000	1.000	1.000	1.000	1.000

Table 5.—Bauxite consumed in the United States in 1968, by grades

(Long tons, dry equivalent)

Grade	Domestic origin	Foreign origin	Total
Crude	1,857,942	95,033	1,952,975
Dried	11,372	11,472,422	11,483,794
Activated	38,699	---------	38,699
Calcined	106,505	515,240	621,745
Total	2,014,518	12,082,695	14,097,213

Calcined aluminas also were used in producing fused alumina and high-alumina ceramics and refractories. Because of properties such as resistance to thermal shock and chemical attack, good thermal conductivity, and high electric resistivity at elevated temperatures, tabular alumina was used in making refractories, electrical insulators, kiln furniture, and as a catalytic support in high-temperature reactions.

Hydrated alumina was used in producing aluminum chemicals, and of these, aluminum sulfate (alum) was produced in the greatest tonnage. Alum was used to fight the growth of algae in northern European lakes.[2] When aluminum sulfate combines with phosphorus in water it flocculates and settles to the bottom, thereby reducing the rate of algae growth and increasing the

Table 6.—Bauxite consumed in the United States, by industries

(Thousand long tons, dry equivalent)

Industry	1967			1968		
	Domestic	Foreign	Total [1]	Domestic	Foreign	Total [1]
Alumina	1,633	11,936	13,570	1,836	11,329	13,165
Abrasive [2]	W	246	[3] 246	W	225	[3] 225
Chemical	130	176	306	135	190	326
Refractory	33	282	315	21	290	311
Other	23	43	66	23	47	70
Total [1] [2]	1,819	12,683	14,503	2,015	12,081	14,097

W Withheld to avoid disclosing individual company confidential data; included with "Other."

[1] Data may not add to totals shown because of independent rounding.

[2] Includes consumption by Canadian abrasive industry.

[3] Excludes domestic.

---

[2] Chemical Engineering. Aluminum Sulfate: New Weapon in War on Algae. V. 75, No. 23, Oct. 21, 1968, p. 68.

oxygen level. Anhydrous aluminum chloride ($AlCl_3$) was used in making ethylbenzene which is used in the production of styrene, in detergent alkylates, in dyestuffs, and in making titanium dioxide pigment.

Table 7.—Production and shipments of selected aluminum salts in the United States in 1967

Item	Number of producing plants	Production (short tons)	Total shipments including interplant transfers	
			Short tons	Value (thousands)
Aluminum sulfate:				
Commercial (17 percent Al_2O_3)	57	1,038,662	1,009,845	$41,473
Municipal (17 percent Al_2O_3)	3	4,732	NA	NA
Iron-free (17 percent Al_2O_3)	20	60,206	36,601	2,247
Aluminum chloride:				
Liquid (32° Be) Crystal (32° Be)	8	22,380	11,684	827
Anhydrous (100 percent $AlCl_3$)	7	37,779	36,223	9,569
Aluminum fluoride, technical	6	131,600	131,481	30,857
Aluminum hydroxide, trihydrate (100 percent $Al_2O_3 3H_2O$)	8	274,825	254,556	19,033
Other inorganic aluminum compounds [1]	NA	NA	NA	16,718
Total	NA	NA	NA	120,724

NA Not available.

[1] Includes sodium aluminate, light aluminum hydroxide, cryolite and alums.

Source: Data are based upon Bureau of the Census report Form MA-28E.1, Annual Report on Shipments and Production of Inorganic Chemicals.

STOCKS

Bauxite stocks, crude and processed, remained almost exactly the same as in the previous year.

Table 8.—Stocks of bauxite in the United States [1]

(Long tons)

Year	Producers and processors		Consumers	
	Crude	Processed [2]	Crude	Processed [2]
1964	1,163,770	10,264	402,394	1,399,509
1965	1,007,020	8,689	419,525	1,609,104
1966	1,129,759	10,424	414,446	2,167,741
1967	1,091,926	9,975	405,870	2,078,018
1968	1,036,665	9,622	292,298	2,247,131

[1] Excludes strategic stockpile.

[2] Dried, calcined, and activated.

Table 9.—Market quotations on alumina and aluminum compounds

Compound	Dec. 18, 1967	Dec. 30, 1968
Alumina, calcined, bags, carlots, works per pound	$0.0530	$0.0530–0.0555
Aluminum hydrate, heavy bags, carlots, freight equalized per pound	.0370–.0400	.0400
Aluminum sulfate, commercial, ground, bags, carlots, works, freight equalized per ton	52.75–56.25	58.25
Aluminum sulfate, iron-free, bags, carlots, works, freight equalized per 100 pounds	3.95–4.0525	4.1525

Source: Oil, Paint and Drug Reporter.

PRICES

According to Oil, Paint and Drug Reporter, the price of bauxite in bulk form from the mines was $7 to $10 per ton. The average value of imported bauxite consumed by domestic alumina plants was $17.15 per long dry ton.

Prices per long ton of imported bauxite quoted in Engineering & Mining Journal at yearend 1967 and 1968 are as follows:

	Atlantic ports, f.o.b. cars	
	December 1967	December 1968
Calcined, crushed (abrasive grade)[1]	[2] $35.00	$35.80
Refractory grade [3]	42.00	43.05
Dried bauxite, crushed, chemical grade (60 percent Al_2O_3, 6 percent SiO_2, 1.25 percent Fe)	15.50–16.50	15.90–16.90

[1] 87 percent minimum Al_2O_3.
[2] Penalties for SiO_2 content more than 7 percent.
[3] 87.5 percent minimum Al_2O_3.

The average value of calcined alumina, as determined from producer reports, was $0.0339 per pound. The value of imported calcined alumina classified as aluminum oxide for use in producing aluminum was $0.0278 per pound.

The average value of crude, undried domestic bauxite, shipments f.o.b. mines or plants, rose from $9.70 per long ton in 1967 to $11.46 in 1968. Data for dried, calcined, and activated bauxite were company confidential.

FOREIGN TRADE

Exports of bauxite totaled 7,321 long tons valued at $359,767 with 98 percent being shipped to Canada and the rest to nine other countries. Exports of alumina rose to about 860,000 short tons valued at $63 million. Of these Ghana received 26, Canada 24, U.S.S.R. 22, Norway 13, and Mexico 8 percent. Shipments were also made to 57 other countries.

Exports of aluminum sulfate rose to 18,250 tons with Venezuela receiving 59, Canada 21, and the Dominican Republic 5 percent. Aluminum hydroxide totaling about 25,550 tons was exported to 54 countries with Sweden receiving 49, Mexico 19, Canada 7, and India 6 percent. Artificial corundum totaling about 15,500 tons valued at $6.3 million was exported, with Canada receiving 55, United Kingdom 11, and Mexico 7 percent, and the Republic of South Africa and West Germany 4 percent each. Of the exports of other aluminum compounds totaling about 30,600 tons valued at $7.7 million, shipments to Ghana constituted 28 percent, to Australia 12 percent, to Colombia 10 percent, to Canada and Norway 9 percent each, and to Surinam and Argentina 6 percent each.

Imports of bauxite decreased to about 11 million long tons; those of alumina rose over 30 percent to 1.3 million short tons.

Table 10.—Average value of U.S. exports and imports of bauxite

(Per long ton)

Type and country	Average value port of shipment	
	1967	1968
Exports: Bauxite and bauxite concentrate	$100.33	$49.14
Imports:		
Crude and dried:		
Australia	7.75	--------
Dominican Republic [1]	15.26	14.83
Greece	7.85	9.09
Guinea	------	4.93
Guyana	9.49	9.06
Haiti [1]	10.87	10.74
Jamaica [1]	14.52	14.45
Surinam	[r] 9.88	9.50
Venezuela	9.13	8.94
Average	[r] 13.06	12.78
Calcined:[2]		
Canada	38.22	43.70
Guyana	31.11	31.41
Surinam	23.10	24.61
Trinidad and Tobago	31.16	--------
Average	29.32	30.43

[r] Revised.
[1] Dry equivalent tons adjusted by the Bureau of Mines used in computation.
[2] For refractory use.
Note: Bauxite is not subject to an ad valorem rate of duty and the average values reported may be arbitrary for accountancy between allied firms, etc. Consequently the data do not necessarily reflect market values in the country of origin.

Table 11.—U.S. imports for consumption of bauxite (crude and dried) by countries[1]

(Thousand long tons and thousand dollars)

Country	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Dominican Republic	653	$9,916	824	$12,574	783	$11,615
Guyana	326	3,219	380	3,612	390	3,532
Haiti	283	3,079	313	3,402	399	4,286
Jamaica	6,665	96,040	6,968	101,223	6,385	92,257
Surinam	3,500	33,860	[r] 2,990	29,553	2,865	27,216
Other countries	102	1,221	119	1,054	154	1,322
Total	11,529	147,335	[r] 11,594	151,418	10,976	140,228

[r] Revised.

[1] Official Bureau of the Census data for Jamaican, Haitian, and Dominican Republic bauxite have been converted to dry equivalent by deducting 13.6 percent free moisture for Jamaican and Haitian, and 17.7 percent for Dominican Republic. Other imports, which are virtually all dried, are on as-shipped basis.

Table 12.—U.S. imports for consumption of alumina for use in producing aluminum, by countries

(Thousand short tons and thousand dollars)

Country	1967		1968	
	Quantity	Value	Quantity	Value
Australia	309	$15,480	698	$37,581
France	25	1,546	----	------
Guinea	21	1,141	----	------
Guyana	26	1,491	24	1,448
Jamaica	130	7,278	109	6,708
Japan	48	2,858	11	601
Surinam	399	20,379	475	26,923
Other countries	----	------	(1)	34
Total	958	50,173	1,317	73,295

[1] Less than ½ unit.

The bauxite came principally from Jamaica (58 percent), and Surinam (26 percent). Alumina (aluminum oxide) imports came primarily from Australia (53 percent), Surinam (36 percent), and Jamaica (8 percent). Imports of aluminum hydroxide from 11 countries totaled 28,671 tons of which 63 percent came from Jamaica, and 33 percent from Canada.

Bauxite import data do not include shipments to the Virgin Islands.

The suspension of duties on crude bauxite, calcined bauxite, and alumina imported for making aluminum was continued until July 15, 1971. On January 1, in accordance with the Kennedy Round trade agreements, duties on aluminum hydroxide and alumina not used for aluminum production were lowered from 0.25 cents to 0.22 cents per pound, that on crude bauxite from 50 cents to 40 cents per long ton, and that on calcined bauxite from 55 cents to 44 cents per long ton.

WORLD REVIEW

In 1968 world bauxite production was about the same as in 1967, which in turn was nearly 10 percent higher than the revised total for 1966. Australian output accounted for 11 percent of the world total and was an increase of 17 percent over 1967 production. This consolidated Australia's third-place position in the free world behind Jamaica and Surinam in which, respectively, output dropped 8 percent and rose 2 percent. Changes in other larger producers were Guyana, up 5 percent; Hungary, up 19 percent; and Greece, up 5 percent.

The ratio of world bauxite to world aluminum production in 1968 was 5.6.

At yearend free world alumina production capacity was estimated as follows:

	Thousand short tons
North America, including Jamaica and Virgin Islands	9,190
South America	1,334
Europe	2,620
Africa	551
Asia	1,558
Oceania	1,747
Total	17,000

Table 13.—World production of bauxite by countries

(Thousand long tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Dominican Republic (shipments)[1]	748	927	820	968	979
Haiti [2]	430	377	356	354	439
Jamaica [1] [3]	7,811	8.514	[r] 8,918	9,121	8,391
United States [1]	1,601	1,654	1,796	1,654	1,665
South America:					
Brazil	130	[r] 185	246	298	[e] 301
Guyana	[r] 2,478	2,873	3,305	3,328	[e] 3,490
Surinam	3,930	[r] 4,291	[r] 5,475	5,380	5,484
Europe:					
Austria	4	--------	--------	--------	--------
France	2,394	2,620	2,766	2,768	2,756
Germany, West	4	4	4	2	NA
Greece	1,030	1,250	[r] 1,349	1,633	[e] 1,722
Hungary	1,454	[r] 1,454	1,406	1,624	1,928
Italy	[r] 243	241	[r] 251	288	218
Rumania [e]	7	[r] 12	[r] 15	15	20
Spain	7	4	2	[e] 2	NA
U.S.S.R.[e] [4]	4,200	4,600	4,700	5,000	5,000
Yugoslavia	1,273	1,549	1,857	2,097	2,037
Africa:					
Ghana	246	314	318	345	--------
Guinea	1,652	1,840	1,583	1,613	--------
Mozambique	6	6	6	6	3
Rhodesia, Southern	2	2	[e] 2	[e] 2	[e] 2
Sierra Leone	151	204	268	336	344
Asia:					
China, mainland [e] [5]	400	400	400	340	374
India	[r] 584	695	738	776	921
Indonesia	688	677	690	906	865
Malaysia:					
Malaya	464	843	940	885	786
Sarawak	158	135	--------	--------	--------
Turkey	4	10	32	21	NA
Oceania: Australia	784	1,168	1,798	4,177	4,880
Total [6]	[r] 32,833	[r] 36,849	[r] 40,041	[r] 43,889	42,880

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Dry bauxite equivalent of crude ore.

[2] Quantities shown include about 14 percent moisture.

[3] Includes bauxite shipped for export and bauxite converted to alumina. May include cement grade bauxite as follows: 1964, 24,144 tons; 1965, 48,293 tons; 1966, 76,094 tons; and 1967, 124,314 tons.

[4] Excludes nepheline concentrates and alunite ores.

[5] Data shown include only bauxite (diasporic) for aluminum manufacture; in addition 100,000 to 200,000 tons was produced each year for refractories.

[6] Totals are of listed figures only.

Australia.—The three main bauxite areas—Weipa in northern Queensland, Gove in Northern Territory, and the Kimberley Plateau in Western Australia—were estimated to contain about 4,500 million tons of commercial grade material. Weipa, the largest producing area, with an estimated 2,500 million tons of reserves grading 50 percent alumina, supplied all the bauxite used by the Gladstone alumina plant.[3] Weipa also supplied the Comalco Industries Pty. Ltd. (Comalco) plant at Bell Bay, Tasmania, and exported bauxite to Japan and Europe. The Western Australia output goes to the Kwinana, Western Australia, alumina plant.

In the Cape York Peninsula, Queensland, Tipperary Land Corp. announced the discovery of about 700 million tons of probable and inferred reserves of bauxitic laterite. Laboratory data showed 36 to 58 percent total alumina and 30 to 49 percent available alumina. The 90-square-mile area is on the western side of the Cape York Peninsula near the Watson River and about 40 miles south of Weipa and 110 miles northwest of Coen. At Gladstone, Queensland Alumina Ltd., owned by Kaiser Aluminum & Chemical Corp. (52 percent), Alcan Aluminium Ltd. (Alcan) (20 percent), Compagnie Péchiney S.A. (Péchiney) (20 percent), and Conzinc Riotinto of Australia Ltd. (8 percent), also was expanding its capacity. By December

---

[3] Light Metal Age. Australian Aluminum Industry Rapidly Expanding Bauxite, Alumina, Ingot Activity. V. 26, Nos. 7 & 8, August 1968, pp. 6–10.

1968, a 336,000-ton expansion raised the rated capacity to a little over 1 million tons.[4] At Weipa, Comalco, jointly owned by Kaiser and Conzinc Riotinto of Australia, was installing a calcination plant, with an initial annual capacity of 112,000 tons by 1970, to produce calcined bauxite for the abrasives industry.

At Gove, Northern Territory, Nabalco Pty. Ltd., 50 percent owned by Swiss Aluminium Ltd. (Alusuisse), 27½ percent owned by Colonial Sugar Refining Co. Ltd., Australia, and the rest by seven other Australian firms, planned to expand the annual capacity of its alumina plant to 560,000 tons by the end of 1971 and to 1.12 million tons by 1974.

Amax Bauxite Corp., a subsidiary of American Metal Climax, Inc., signed an agreement with the Western Australia Government defining the conditions under which the firm would be granted a mineral lease over bauxite deposits it found in the Kimberley area in 1965.[5] Although mine development work continued, and an engineering study will serve as a basis for evaluating the viability of a mine and adjacent 600,000-ton-per-year alumina plant, the remote area and high development costs require a large production complex for which a consortium is most feasible. The deposits, which are believed to contain more than 100 million tons, occur on the Mitchell Plateau in far northwest Western Australia, between Montague Sound and Napier Broome Bay. An estimated 90 million tons of commercial low-grade (31 percent alumina) bauxite was found in drilling in the Chittering area north of Perth.

Western Aluminium Pty. Ltd., a subsidiary of Alcoa of Australia Pty. Ltd., which itself is 51 percent owned by Aluminum Company of America (Alcoa) and 49 percent by Western Mining Corporation, Ltd., Broken Hill South Ltd., and North Broken Hill Ltd., was bringing its alumina plant at Kwinana, Western Australia, to an annual capacity of 915,000 tons by the second half of 1969. A fifth unit will bring the total capacity to 1.145 million tons in the second half of 1970.

Costa Rica.—In November, Alcoa signed a contract with the Government of Costa Rica which provided for the construction of a $60 million, 440,000 ton-capacity alumina plant in San Isidro del General. Port facilities will be built at Punta Uvita in Puntarenas Province on the Pacific Coast. The 25-year agreement is automatically renewable for an additional 25 years if Alcoa spends $150 million in the country in the first 25 years. Alcoa will be able to utilize 165 million tons of dry bauxite in the concession area for its plant. All bauxite remaining in the concession area will be split 50-50 with the Government.

Fiji.—Japan's interest in bauxite supplies extended to these islands, when three Japanese aluminum producers—Nippon Light Metal Co. Ltd. (NKK), and Showa Denko K.K. of Tokyo and Sumitomo Chemical Co. Ltd. of Nishinomiya City—formed Bauxite Fiji Ltd. which hopes to work bauxite deposits at Wainunu on Vanua Levu, the second largest island in the group. The deposits were estimated at about 6 million tons.

France.—New port facilities at Fos, near Marseilles, will accommodate the largest ore carriers. With these facilities, the French alumina industry now will be able to import Australian bauxite at rates less than the cost of domestically mined ore.

At Saint Louis-les-Aygalades, Bouches du Rhône, Société Française pour l'Industrie de l'Aluminium (S.F.I.A.), a member of the Alusuisse group, closed its 66,000-ton alumina plant, which is small by today's standards. This reflects dwindling reserves in Var, mined by Société Anon. des Bauxites de France, high mining costs, and the group's investment in overseas production facilities.

Ghana.—The British Aluminium Company, Ltd., further developed its bauxite deposits at Awaso, announcing that by early 1969 a new plant will be able to produce about 450,000 tons of treated bauxite ore per year.

Greece.—The Eleusis Bauxite Mining Co. located a bauxite deposit on the slopes of Mount Oete, a northern continuation of the Parnassus Range. The firm planned also to modernize and expand facilities at its mines in Eleusis and near Lamia.

Greek mining firms continued to supply the needs of the country's sole alumina producer, Aluminium de Grèce, S.A., as well as meet export quota commitments.

---

[4] Alcan Aluminium Limited. 1968 Annual Report. Feb. 12, 1969, 33 pp.

[5] American Metal Climax, Inc. Annual Report 1968. Mar. 17, 1969, 38 pp.

The Greek Ministry of Commerce had fixed the 1968 bauxite export allocation at 1,697,000 tons compared with 1,488,120 tons in 1967. The increase was due mostly to larger shipments to the United States and to new large shipments to Czechoslovakia, Japan, and Yugoslovia.

Aluminium de Grèce planned to enlarge the capacity of its Paralia-Distomon plant from 280,000 tons to 560,000 tons alumina per year. Another 560,000 ton plant is to be erected by the Onassis-Reynolds Metals Co. group. This plant will be half completed by 1973 and fully completed by 1978.

Guinea.—Bauxite was shipped from operations on the Island of Tamara, offshore from Conakry, to the Harvey alumina plant in the Virgin Islands.[6]

In September the International Bank for Reconstruction and Development lent $64.5 million to the Government of Guinea to help develop the Boké deposit at Sangaredi, northwest Guinea. The mining and processing facilities will be developed by the Compagnie des Bauxites de Guinée, owned 51 percent by Halco (Mining) Inc., a U.S. firm, and 49 percent by the Government of Guinea. Halco is a consortium of the American firms, Alcoa, 27 percent and Harvey, 20 percent; Alcan, 27 percent; Péchiney and Ugine Kuhlmann Société, France, 10 percent; Vereinigte Aluminium-Werke A.G., West Germany, 10 percent; and Montecatini Edison S.p.A., Italy, 6 percent.

A railway will be built from the mine site to the port of Kamsar 85 miles away. Facilities to be built at the port will handle 8.8 million tons of bauxite per year. Initial production from the mine is slated for 1972 at an annual rate of 5.2 million tons of bauxite and from the treatment plant, 220,000 tons of calcined bauxite. Late in the year the U.S. Export-Import Bank lent the Compagnie des Bauxites de Guinée $25 million to finance purchases from the United States of bauxite mining, transporting, crushing, drying, calcining, and handling equipment. The U.S. Agency for International Development (AID) also will advance $21 million of local currency.

Also late in the year, the Government agreed to allow Compagnie Internationale pour le Production de l'Alumine (Fria) to expand its bauxite mining and alumina refining operation, the latter from 580,000 to 770,000 tons annually by 1970. Shareholders in the firm are Olin Mathieson Chemical Corp., United States, 48.5 percent; Péchiney and Ugine Kuhlmann Société, 26.5 percent; Alusuisse, 10 percent; The British Aluminium Co. Ltd., 10 percent; and Vereinigte Aluminium-Werke A.G., 5 percent.

Guyana.—Demerara Bauxite Company, Ltd., a subsidiary of Alcan, expanded its bauxite mining and calcining capacities.[7] It was expected that rated capacity of the alumina plant could be increased 20 percent by 1971.

Hungary.—When it reaches full production capacity, the Halimba mine located in the Bakony Mountains, will have an output of about 660,000 tons per year, placing it ahead of the Gant mine in the Vertes area as Hungary's largest bauxite mining operation.

At Almásfüzitö, the capacity of the country's largest alumina plant will be increased from 175,000 to 320,000 tons per year, when a new 500-ton-per-day calcining kiln is fully operational. The new kiln is 4½ times as large as the existing units.

India.—An alumina plant, part of an integrated smelter project, was being built south of Bombay by Indian Aluminium Co., Ltd., a subsidiary of Alcan.[8]

Indian reserves of bauxite of all grades were estimated at 304 million tons, of which 80 to 85 million tons are regarded as of high grade—containing over 50 percent alumina.[9] Reserves of the higher grade bauxite are listed below by State.

State	*Million tons*
Madhya Pradesh	19.3
Bihar	14.2
Jammu and Kashmir	14.3
Gujarat	14.0
Maharashtra	11.7
Madras	4.4
Mysore	1.3
Orissa	0.8
Total	80.0

---

[6] Harvey Aluminum (Incorporated). Annual Report for the Fiscal Year Ended Sept. 30, 1968. 40 pp.

[7] Work cited in footnote 4.

[8] Work cited in footnote 4.

[9] Pande, P.C. A Note on the Bauxite Deposits of India. J. Mines, Metals and Fuels, v. 16, No. 4, April 1968, pp. 113–115.

Currently bauxite production comes from the States of Bihar, Gujarat, Madhya Pradesh, Madras, Maharashtra, and Mysore. Recent discoveries include additional deposits in Gujarat and sizable deposits in Kerala State. Bauxite supplies for Indian metal producers come from the Ranchi area in Bihar and from the Amarkantak area in Madhya Pradesh, where the Hindustan Aluminium Corp. Ltd., a venture of Kaiser and the Birla group of industries in India, operates fully mechanized mines. At the Bagru Hill mine near Ranchi in the Lohardaga area, Indian Aluminium Co. Ltd. is converting to mechanized mining methods. Mining methods used in the Shevaroy Hills, Salem District, Madras, to obtain ore for Madras Aluminium Co. Ltd. and those used at the Ranchi area mines in Bihar owned by Aluminium Corp. of India Ltd. were still rather primitive.

India probably will have trouble in the near future exporting bauxite to foreign users because of inefficient land transportation and port facilities which raise the price of Indian bauxite.

Large reserves in the Kutch and Jamnagar districts of Gujarat State on the west coast, led the Gujarat Mineral Development Corp. to announce it will establish an alumina plant, with a capacity of 165,000 tons per year. An alumina plant, with an annual capacity of 220,000 tons, was being built at Korba, Madhya Pradesh, with Hungarian aid. Also, another smaller (55,000-ton) alumina plant project, to be erected at Ratnagiri, West Bombay, with Hungarian financial assistance, was approved by the Indian Finance Ministry and the Planning Commission.

Indonesia.—At yearend, after being stalled by tax difficulties, the Government and Alcoa neared signing a contract to give Alcoa a large prospecting area for bauxite in and around Sumatra and southeast Celebes. In addition, if feasible, an alumina plant would be built on Sumatra.

Three Japanese aluminum companies—NKK, Sumitomo Chemical Co. Ltd., and Showa Denko KK—obtained permission from the Government to explore for bauxite for 2 years on the island of Bintan. If at least 40 million tons of low-grade bauxite is found, the firms will build an alumina plant.

Italy.—Eurallumina S.p.A., owned by Alsar S.p.A., Comalco, and Metallgesellschaft A.G., planned to build and operate an alumina plant in the Sulcis-Iglesiente industrial zone in Sardinia. The plant, with an initial capacity of 670,000 tons but ultimately enlargeable to 2.2 million tons, will be adjacent to the 112,000-tons-per-year primary aluminum plant now being built by Alsar, which is owned by the State Industrial Holding Company (E.F.I.M.), Montecatini Edison S.p.A., and the Société Traction et Electricité. The alumina plant, scheduled for completion in late 1971, will use Australian bauxite supplied by Comalco's parent companies.

Jamaica.—In the southwest part of the country, Revere Jamaica Alumina, Ltd., a subsidiary of Revere Copper and Brass Inc., acquired land for mining bauxite and installing a 220,000-ton alumina plant, to be completed in 1971. Reserves in the area are expected to be sufficient for 40 years. Later the plant will be enlarged, in two stages, to 440,000 and 660,000 tons annual capacity.[10]

Three companies—Reynolds Jamaica Alumina Ltd. Kaiser Jamacia Corp., and Anaconda Jamaica Inc.,—participated in the $175 million, 950,000 ton-capacity Alumina Partners of Jamacia (Alpart) alumina plant, in St. Elizabeth's Parish near the south coast, which was scheduled to be on-stream in mid-1969. Alcan Jamaica Limited completed expansion of its annual alumina capacity to 1.225 million tons.[11]

By 1971, Alcoa Minerals of Jamaica, Inc., a wholly owned subsidiary of Alcoa, will build, own, and operate a 440,000-ton-per-year alumina plant at Woodside, Clarendon Parish. Eventually the plant size will be doubled. Alcoa signed an agreement with the Government of Jamaica for additional mining leases to provide a reserve supply of bauxite for the plant's operation.

Japan.—NKK, owned 50 percent by Alcan, expanded its alumina plant at Shimizu and started building another 350,000 ton per year plant at Tomakomai on Hokkaido.[12]

Early in the year, Showa Denko K.K. decided to raise the annual capacity of its

---

[10] Revere Copper and Brass Incorporated. Annual Report 1968. Mar. 28, 1969, 28 pp.

[11] Work cited in footnote 4.

[12] Work cited in footnote 4.

Yokohama alumina plant from 220,000 to 480,000 tons and at yearend announced plans for a further expansion to 550,000 tons. Also, by the end of 1968, Sumitomo Chemical Co. Ltd. had expanded the annual capacity of its Kikumoto alumina plant to 440,000 tons.

Malagasy Republic.—Exploratory rights until 1970 were awarded by the Malagasy Government to Péchiney. Subsequently the French firm located major concentrations of bauxite in the Manantenina area near Fort Dauphin in the south of the country and also in an area stretching 300 kilometers between Vangaindrano and Fort Dauphin.

Rumania.—The annual capacity of the Oradea alumina plant was being raised to 224,000 tons to supply the Slatina aluminum smelter on the river Olt which is raising its annual capacity to 112,000 tons.

Surinam.—The alumina plant at Paranam, operated by Suriname Aluminum Co. (Suralco), added a fifth refining unit making the facility the world's largest alumina plant, with a yearly capacity of 1.25 million tons.[13]

A consortium comprised of Suralco; N.V. Billiton Maatschappij Suriname, a subsidiary of N.V. Billiton Maatschappij of the Netherlands; Alcan; and Ormet Corp., a joint venture of Olin Mathieson Chemical Corp. and Revere Copper and Brass Inc., concluded an agreement with the Government for exploration in western Surinam. Pending successful exploration, a mining license will be granted if the consortium agrees to build and operate an alumina plant of at least 450,000 to 560,000 tons annual capacity. It was reported also that the Kabalebo Joint Venture, consisting of Kaiser Aluminum & Chemical Corp. and Péchiney, had agreed with the Surinam Government on the basic points for a bauxite exploration and mining concession in western Surinam.

United Arab Republic.—Reserves estimated at 60 million tons of bauxite were located in the Gebel Abu Churuk region of the Eastern Desert of Egypt.

United Kingdom.—The Refractories and Electronics Division, Carborundum Ltd., announced that a new factory for manufacturing oxide refractories was being built at Rainford, Lancashire. Products will include abrasion resistant aluminum oxide compositions, high-purity aluminum oxide compositions, and mullite compositions.

Yugoslavia.—The Government-owned alumina concern planned to install a 220,000-ton-per-year alumina plant at its facilities in Mostar, Bosnia-Hercegovina by 1970.

TECHNOLOGY

Research on the optimum recovery of alumina from processed red mud centered on using batch and continuous centrifuges to increase the solids content of the mud from the range of 20 to 25 percent up to about 40 percent.[14] A clear effluent, containing a substantial quantity of dissolved alumina and soda which was recovered, has potential for recycling to the alumina plant. A cost analysis was made for a proposed plant handling 16,000 tons of red mud daily.

Efforts to find technically feasible processes for treating low-grade aluminous materials for their alumina content continued. Some of this consisted of developing and evaluating techniques on materials such as anorthosite, clay, and low-grade bauxites. Anorthosite, treated with soda ash and limestone, formed a sinter which was leached with dilute sodium carbonate solution. The sodium aluminate formed during leaching was separated from the residue and treated with lime in autoclaves to remove dissolved silica. Then the alumina trihydrate was precipitated with carbon dioxide and calcined to alpha alumina.[15] A 1,000-ton-per-day alumina plant, using dry grinding in the sintering step, could produce alumina at an estimated cost of $75.40-per-ton, when $2.50-per-ton anorthosite and $1-per-ton limestone are the raw materials. Wet grinding would cost about $1 per ton less. Currently, however, the method is not competitive with the

---

[13] Aluminum Company of America. 1968 Annual Report. Feb. 20, 1969, 32 pp.

[14] Good, Philip C., and O. C. Fursman. Centrifugal Dewatering of Jamaican Red Mud. BuMines Rept. of Inv. 7140, June 1968, 10 pp.

[15] Johnson, Paul W., and Frank A. Peters. Methods for Producing Alumina from Anorthosite. An Evaluation of a Lime-Soda Sinter Process. BuMines Rept. of Inv. 7068, January 1968, 42 pp.

Bayer process for treating bauxite to produce alumina. Also, siliceous, titaniferous, and ferruginous bauxites were smelted with coke and lime in an electric-arc furnace to produce calcium aluminate slags which were then treated with sodium carbonate solution.[16] Over 90 percent alumina was recoverable when the slags were of properly controlled ternary phase composition cooled slowly enough to permit adequate crystallization of several phases, including the calcium aluminate compounds. Bureau scientists also estimated that waste solutions from domestic copper leaching plants, from clay processing and uranium plants, and in acid drainage from certain iron and coal mines contain thousands of tons of alumina which are discarded daily.[17] Initial laboratory tests using solvent extraction show that alumina could be recovered from copper mine waste water for $51 to $58 per ton compared with an average of about $56 per ton of imported Bayer process alumina. In a method used in the Nowiny cement works in Poland, alumina production coupled with that of cement is claimed to reduce the oxide price by 25 percent and to increase the output of the cement kilns by about two percent.[18] The feed material for this plant consists of waste carbon shales mixed with limestone, which are sintered in a rotary coal-dust fired cement kiln with the main sinter ingredients being calcium orthosilicate and clay and calcium minerals. Subsequently, in cooling, the orthosilicate, containing calcium aluminates, decomposes, and after a series of dissolutions, decantings, and desilications, aluminum hydroxide is separated and calcined to alumina.

A technically satisfactory calcination process for Alabama bauxite (mixtures of gibbsite and kaolinite) using existing equipment was established.[19] Large-scale experiments were conducted in a plant designed for calcining refractory clay with firing temperatures up to 3,000° F and a 1 hour retention time in the kiln.

The value of alumina in ceramic bodies continued to be extended by research. Combined quenching (thermal conditioning) and glazing with low-expansion glazes made possible unusually strong alumina bodies.[20] It was necessary to use the finest crystalline, fully ground alumina in making a 99.8 percent alumina grinding ball which possesses maximum density and abrasion resistance.[21]

---

[16] Fursman, Oliver C., Henry E. Blake, Jr., and James E. Mauser. Recovery of Alumina and Iron from Pacific Northwest Bauxites by the Pedersen Process. BuMines Rept. of Inv. 7079, February 1968, 22 pp.

[17] Secondary Raw Materials. Mineral Wastes May Be Source of Alumina. V. 6, No. 3, March 1968, p. 9.

[18] Alumina Without Bauxite. Mining Magazine. V. 119, No. 2, August 1968, p. 113.

[19] Bakker, Walter T. General Refractories Research Project Reveals Hi Grade Domestic Bauxite. Brick & Clay Record, v. 153, No. 2, August 1968, pp. 24–26.

[20] Kirchner, H. P., R. M. Gruver, and R. E. Walker. Strengthening Alumina by Glazing and Quenching. Am. Ceram. Soc. Bull. v. 47, No. 9, September 1968, pp. 798–802.

[21] Pearson, Alan, J. E. Marhanka, George MacZura, and LeRoy D. Hart. Dense, Abrasion-Resistant 99.8% Alumina Ceramic. Am. Ceram. Soc. Bull., v. 47, No. 7, July 1968, pp. 654–658.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/50

Beryllium

By Henry C. Meeves[1]

World production and U.S. imports of beryl decreased in 1968, while U.S. consumption increased. Domestic output of beryl remained at a low level. Progress continued on The Brush Beryllium Co.'s new facilities in Utah, which are projected to be on stream in mid-1969.

Legislation and Government Programs.—Government inventories of beryl ore decreased by 4,076 short tons, while inventories of beryllium metal increased by 27 short tons. Congress approved the release of 9,888 short tons of beryl, of which 4,000 are to be sold prior to June 30, 1969, and the remainder prior to June 30, 1971. Slightly more than 1,500 short tons (16,857 short-ton units of beryllium oxide) were sold in September to The Brush Beryllium Co., C. Tennant & Sons Co., and Metallurg Inc. Bids were opened in December for the sale of an additional 1,500 short tons.

DOMESTIC PRODUCTION

Hand-sorted beryl was produced in Colorado, New Mexico, and South Dakota. Individual company data are confidential, but the reported total output was small.

Table 1.—Salient beryl statistics

	1964	1965	1966	1967	1968
United States: Beryl, approximately 11 percent BeO unless otherwise stated:					
Domestic beryl shipped from mines short tons	W	W	W	W	168
Imports do	5,425	7,791	2,147	9,511	3,822
Consumption do	4,435	5,845	6,026	7,087	8,719
Price, approximate, per unit BeO imported, cobbed beryl at port of exportation	$23	$24	$25	$30	$34
World: Production short tons	4,916	6,123	4,549	5,423	6,116

W Withheld to avoid disclosing individual company confidential data.

Table 2.—Government yearend stocks of beryllium materials

(Short tons)

Material	National stockpile	Supplemental stockpile	Commodity Credit Corporation	All stocks
Beryl (11 percent BeO):				
Objective	13,622	1,593	----------	15,215
Excess	7,404	4,568	----------	11,972
Total	21,026	6,161	----------	27,187
Beryllium-copper master alloy:				
Objective	----------	----------	----------	4,750
Excess	(1)	(1)	----------	(1)
Total	1,075	6,312	----------	7,387
Beryllium metal:				
Objective	----------	150	----------	150
Excess	----------	75	4	79
Total	----------	225	4	229
On order	----------	----------	25	25

(1) No excess shown in this commodity due to a deficit in copper.

Source: Office of Emergency Planning. Supplemental Stockpile Report to the Congress. OEP-4, July-December 1968.

---

[1] Mining engineer, Denver Office of Mineral Resources, Denver, Colo.

Kawecki Berylco Industries, Inc. with plants in Reading, Hazleton, and Boyertown, Pa., and The Brush Beryllium Co. of Elmore, Ohio, processed imported, hand-sorted beryl into beryllium metal, alloys, and compounds. Outputs were principally beryllium and beryllium-copper master alloys. Kawecki Berylco Industries Inc. resulted from the merger in October of The Beryllium Corp. (Berylco) and Kawecki Chemical Co. The Brush Beryllium Co. completed stripping of 1.75 million cubic yards at its Spor Mountain, Utah, property in November. The company's new $9 million processing facilities were approximately 50 percent complete by yearend and are expected to be on stream by mid-1969. The company was awarded the initial Lockheed contract to supply rough-machined beryllium parts that will be fabricated into a heat sink for the U.S. Navy's Poseidon missile program; the contract totaled $14 million. Lockheed also announced a $3 million contract to Berylco in September to develop and supply beryllium parts for the Poseidon program. The Anaconda Company continued development work and utilization studies on property south of Brush's open pit mine, located on the west side of Spor mountain 50 miles northwest of Delta, Utah. General Astrometals Corp., Yonkers, N.Y., a subsidiary of Anaconda, continued to produce beryllium shapes from various types of beryllium. Beryllium Metals & Chemicals Corp., a subsidiary of Lithium Corporation of America, Inc., continued to produce and fabricate electrorefined beryllium. At yearend the company was studying the market with a view to shutting down its operation.

CONSUMPTION AND USES

Consumption of hand-cobbed beryl by the beryllium and ceramic industries totaled 8,719 short tons, an increase of 1,600 tons over that of 1967. Kawecki Berylco Industries and The Brush Beryllium Co. were the largest consumers. Beryl Ores Co., Arvada, Colo., purchased cobbed beryl to produce specialized materials for the ceramic and other industries. Ground beryl was used by Lapp Insulator Co., Le Roy, N.Y., in making high-voltage electrical porcelain. The Ceramic Division, Champion Spark Plug Co., Detroit, Mich., used cobbed beryl as a minor constitutent in special ceramic compositions, principally for spark plugs.

The bulk of the increase in consumption probably reflected the processing of ore to in–process–inventory in anticipation of larger requirements in the near future.

Beryllium was used extensively in research and development, mainly by aerospace designers and developers, because of its low density, high modulus of elasticity, high-heat capacity, unique stiffness-to-weight ratio, and nuclear properties. Development and evaluation progressed further in the use of beryllium in structural components, aircraft brakes and rudders, missile parts, jet engine parts, inertial guidance systems, and rocket-fuel additives; however, there has been only sporadic use in nuclear applications because of high costs.

Beryllium-copper alloys are the principal support of the beryllium industry. The alloys, well known for their outstanding strength and thermal and electrical conductivity, had thousands of uses in business machines, electronic devices, computers, automobiles, aircraft, household appliances, boats, and spacecraft. Research continued in beryllium alloying for the purpose of increasing ductility and die life. One application, plating beryllium-nickel strip with cadmium, increased die life 900 percent.

Greater applications of beryllium oxide in electronics and ceramics are being considered.

STOCKS

Consumers' stocks of beryl at yearend totaled 6,390 short tons. Dealers' stocks were unknown.

PRICES AND SPECIFICATIONS

Prices of domestic and imported beryl were negotiated between buyers and sellers, and not quoted in the trade press. The average price of imported beryl at foreign ports was $370 per short ton. Quoted prices for beryllium metal, powder blend, and vacuum-cast ingot remained unchanged in 1968. Three major changes in the price of beryllium-copper occurred during the year, and by yearend, beryllium-copper master alloy, f.o.b. Reading, Pa., Detroit, Mich., and Elmore, Ohio, was quoted at $48 per pound of contained beryllium, with the copper content priced as of shipment date. Beryllium-copper (No. 172) strip, rod, bar, and wire were quoted at $2.72 per pound. Throughout the year beryllium-aluminum was quoted in American Metal Market at $62 per pound of contained beryllium, with the aluminum content priced at current market levels.

FOREIGN TRADE

Exports of various forms of beryllium and beryllium-base alloys increased 23 percent over those of 1967, mostly because of greatly increased exports to West Germany and the United Kingdom. For the first time since 1963 imports of beryllium metal from France declined.

Table 3.—U.S. exports of beryllium alloys, wrought or unwrought, and waste and scrap[1]

Country	1967		1968	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Australia	5	(2)	------------	------------
Austria	1	(2)	------------	------------
Belgium-Luxembourg	----------	---------	51	$1
Canada	23,029	$97	2,273	102
France	1,326	33	915	65
Germany, West	24,538	107	55,994	208
Greece	939	3	------------	------------
India	----------	---------	304	1
Israel	----------	---------	2	(2)
Italy	55	4	12	1
Japan	6,356	181	6,162	124
Mexico	2,222	2	1,040	1
Netherlands	25	4	48	1
Spain	----------	---------	22	1
Switzerland	10	3	------------	------------
United Kingdom	17,516	96	26,652	117
Venezuela	95	(2)	------------	------------
Total	76,117	530	93,475	622

[1] Consisting of beryllium lumps, single crystals, and powder; beryllium-base alloy powder; and beryllium rods, sheets, and wire.

[2] Less than ½ unit.

Table 4.—U.S. imports for consumption of beryl, by customs district and countries

Customs district and country	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Philadelphia district:				
Argentina	313	$101	549	$214
Australia	414	140	124	53
Bolivia	----------	----------	15	5
Brazil	1,173	388	1,600	579
Burundi and Rwanda	100	24	176	60
India	1,500	425	----------	----------
Italy	1,316	472	----------	----------
Kenya	33	9	56	12
Malagasy Republic	12	4	52	16
Mozambique	141	43	140	88
Portugal	15	5	67	29
Rhodesia, Southern	47	14	97	32
South Africa, Republic of	197	63	359	131
Spain	----------	----------	23	7
Uganda	235	62	398	129
Zambia	----------	----------	3	1
Total	5,496	1,750	3,659	1,356
New York City district:				
Australia	----------	----------	31	11
Brazil	53	19	99	34
Burundi and Rwanda	44	13	----------	----------
Uganda	----------	----------	33	12
Total	97	32	163	57
Baltimore district:				
India	3,907	1,382	----------	----------
Norway	10	3	----------	----------
Total	3,917	1,385	----------	----------
El Paso district: Zambia	1	(1)	----------	----------
Grand total	9,511	3,167	3,822	1,413

[1] Less than ½ unit.

Table 5. U.S. imports of beryllium products in 1968, by countries

Country	Beryllium, unwrought, waste and scrap		Beryllium, wrought	
	Pounds	Value (thousands)	Pounds	Value (thousands)
France	11,658	$746	2	$1
India	1,231	79	--------	--------
Japan	603	11	8	1
United Kingdom	473	5	--------	--------
Total	13,965	841	10	2

WORLD REVIEW

India.—The government classifies beryl as a mineral strategic to its national defense, thus placing production and related statistics under control of the Department of Atomic Energy. This agency does not report production data. Official trade statistics list beryl as an export commodity, but quantity and value are not shown.

Beryl is known to occur in pegmatite intrusives in Rajasthan, Bihar, Andhra Pradesh, Madras, Mysore, Madhya Pradesh, and Himachal Pradesh, and in nonpegmatitic deposits in Rajasthan and Gujarat. The only deposits of economic importance have been pegmatitic, particularly those in Rajasthan and Bihar.

Although it has been generally believed that Indian beryl is a byproduct of mica mining, this source accounts for only a small proportion of the total recoveries. The quantities recovered from individual mines are small, but the number of important, known deposits is large. Beryl in these deposits is mined by private operators, using open-pit, hand methods.

Table 6.—World production of beryl, by countries

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
Argentina	208	248	[r] 281	[p] 295	NA
Australia	125	44	[r] 58	[r] 61	• 11
Brazil [1]	1,566	1,227	[r] [2] 878	1,444	2,291
Congo (Kinshasa)	[r] 186	21	---------	2	---------
India [3]	[r] NA	[r] 2,001	[r] 1,466	[r] 1,433	• 1,433
Malagasy Republic	234	22	18	33	85
Mozambique	[r] 422	[r] 242	88	186	104
Portugal	20	44	[r] 13	[r] 15	• 100
Rhodesia, Southern	182	[2] 101	[r] [2] 72	[2] 47	NA
Rwanda	828	756	147	120	31
South Africa, Republic of	151	[r] 46	[r] 23	[r] 115	240
South-West Africa	8	57	24	NA	NA
Uganda	434	212	273	344	• 330
U.S.S.R.• [4]	1,102	1,102	1,213	1,328	1,323
United States (mine shipments):					
Cobbed beryl	W	W	W	W	168
Total [5]	[r] 4,916	[r] 6,123	[r] 4,549	[r] 5,423	6,116

• Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Exports.

[2] U.S. imports.

[3] Data for 1965–67 are exports to United States as reported by Indian Department of Atomic Energy.

[4] Cobbed concentrates at about 11 percent BeO.

[5] Totals are of listed figures only.

The Geological Survey of India and the Department of Atomic Energy have been conducting extensive surveys for several years in known beryl-bearing areas. A recent project was undertaken to locate new deposits and assist mine operators. Accelerated exploration efforts and recommendations to extend open pits to depths beyond 200 feet indicate that programs to increase reserves, conserve resources, and improve mining methods are in progress.[2]

TECHNOLOGY

Geochemical studies of stream sediments, soils, and rocks have detected patterns in the distribution of beryllium, tin, copper, and lead in the Lake George, Colo., area.[3]

A study was initiated by the U.S. Department of Health, Education, and Welfare, Environmental Control Administration, on the potential danger of pulmonary berylliosis.

The effects of mechanical behavior, pressure-cycling, and tensile prestraining were investigated, using hydrostatic pressure up to 400 kips per square inch at 25° to 300° C on hot-pressed block, extruded rod, and cross-rolled sheet. For all three materials the ductility increased with pressure, whereas the flow stress did not appear to be significantly influenced by pressure. An increase in yield strength generally occurred with pressure-cycling or prestraining under pressure, with no change or a decrease in ductility. The effects of pressure-cycling and prestraining were relatively independent of the temperature at which the investigation was conducted.[4]

---

[2] Bureau of Mines. Mineral Trade Notes. V. 65, No. 10, October 1968, pp. 6–7.

[3] Hawley, C. C., and W. R. Griffitts. Distribution of Beryllium, Tin, and Tungsten in the Lake George Area, Colorado. U.S. Geol. Survey Circ. 597, 1968, 18 pp.

[4] Inoue, N., V. Damiano, J. Hanafee, and H. Conrad. Effects of Hydrostatic Pressure on the Mechanical Behavior of Polycrystalline Beryllium. Trans. Metallurgical Soc. AIME, v. 242, No. 10, October 1968, pp. 2081–2089.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-05[illegible]/184

Bismuth

By Harold J. Schroeder [1]

The domestic bismuth industry in 1968 experienced reduced consumption accompanied by a strike-curtailed primary output during the early part of the year, decreased imports, significant sales of Government surplus stockpiled bismuth, and a drawdown of industrial stocks. The year ended with the U.S. supply and demand about in balance but with stocks at a low level both here and in Europe, leading to reported premiums being paid above producer quotes in Europe. With no apparent new sources of bismuth supply, the 1969 availability of bismuth from producers may fall short of demand and accelerate sale of Government surplus stockpile bismuth.

Table 1.—Salient bismuth statistics

(Pounds)

	1964	1965	1966	1967	1968
United States:					
Consumption	2,160,100	2,931,673	3,199,321	2,513,652	2,347,768
Exports [1]	61,299	341,868	89,382	152,684	120,466
Imports, general	1,238,252	1,378,147	1,681,472	1,379,729	1,265,671
Price: New York, average ton lots	$2.30	$3.43	$4.00	$4.00	$4.00
Stocks Dec. 31: Consumer and dealer	656,900	506,300	651,800	659,600	621,500
World: Production	6,375,667	6,525,000	6,859,244	7,630,341	7,589,000

[1] Includes bismuth, bismuth alloys, and waste and scrap.

Legislation and Government Programs.—The General Services Administration in accord with legislation enacted November 30, 1967, to dispose of 1.2 million pounds of surplus bismuth, established a program to make available for sale 300,000 pounds for the period through March 21, 1968, and 150,000 pounds for each calendar quarter thereafter. The bismuth was priced at $4 per pound in 1-ton lots, f.o.b. destination within the continental United States, excluding Alaska. Sales during 1968 totaled 314,000 pounds with 81,500 pounds during the first quarter, 146,000 pounds during the second quarter, 54,000 pounds during the third quarter, and 32,500 pounds during the fourth quarter. At yearend 821,500 pounds remained available for sale.

Government stockpiles were reduced to 3.41 million pounds and the surplus inventory to 1.01 million pounds, of which the Atomic Energy Commission has prior authorized withdrawal rights to 200,000 pounds. The stockpile objective remained 2.4 million pounds.

DOMESTIC PRODUCTION

Production from primary material in 1968 declined about 24 percent, a continuation of the downward trend since 1965. Refining of primary bismuth was carried on at the East Chicago plant of the United States Smelting, Refining and Mining Co. and at the Omaha, Neb., plant of American Smelting and Refining Company (Asarco). Output at Asarco was curtailed during the first 4 months of the year owing to continuation of a strike initiated in July 1967. Recovery of bismuth from scrap increased at the Franklin Park, Ill., plant of United Refining & Smelting Co. Fred H. Lenway & Co. and Southern California Chemical

---

[1] Physical scientist, Division of Mineral Studies.

Inc., in a joint venture began production of bismuth from spent acrylonitrile catalyst in the third quarter of 1968 with initial processing at Texas City, Tex., and final extraction at Los Nietas, Calif. The combined output of bismuth from primary and secondary sources declined about 21 percent.

CONSUMPTION AND USES

Consumption of bismuth decreased 7 percent to 2.3 million pounds, the smallest quantity since 1964. The decline was almost entirely in the category of fusible alloys. The category of pharmaceuticals, which includes industrial and laboratory chemicals, remained unchanged. A factor in the industrial chemical consumption was the use of bismuth as a catalyst in the manufacture of acrylonitrile fiber; this use grew to a peak in 1966, declined sharply in 1967, and leveled off in 1968. The leveling off was attributed in part to the completion of required stocks of the catalyst at certain plants and to the use of a spent uranium catalyst as a substitute. Another industrial bismuth chemical used to produce a pearlescent quality to cosmetics, enamels, and other materials may have an increasing application, particularly in plastics. "Other alloys," which are predominantly metallurgical additives to aluminum, malleable iron, and special steels to improve machinability, had little change in consumption.

Table 2.—Bismuth metal consumed in the United States, by uses

(Pounds)

Use	1967	1968
Fusible alloys [1]	826,528	675,416
Other alloys	456,246	454,519
Pharmaceuticals [2]	1,211,668	1,210,396
Experimental uses	9,438	215
Other uses	9,782	7,222
Total	2,513,652	2,347,768

[1] Includes 170,837 pounds of bismuth contained in bismuth-lead bullion used directly in the production of an end product in 1967 and 106,104 pounds in 1968.

[2] Includes industrial and laboratory chemicals.

STOCKS

Stocks of bismuth metal held by consumers and dealers increased from 660,000 pounds at the start of the year to a relatively high level of 797,000 pounds at the end of the third quarter and then were drawn to 621,500 pounds at yearend, the lowest yearend quantity since 1965. Metal stocks at domestic producers declined slightly to a very low operating level.

PRICES

The delivered price of refined bismuth metal, as quoted by Metals Week (New York), was stable at $4 per pound in 1-ton lots, effective June 21, 1965. The London Metal Bulletin also quoted $4 per pound (U.S. equivalent) in ton lots throughout the year. Dealer or merchant prices in the United States and Europe were reported to correspond with producer quotes except for late in 1968 when, in Europe, premiums above the producer price developed owing to reduced availability of bismuth.

FOREIGN TRADE

Exports of bismuth, predominantly in the form of alloys and compounds, decreased in 1968 to 120,466 pounds gross weight, valued at $292,000. Shipments were approximately 42 percent to the Netherlands, 32 percent to the United Kingdom, 10 percent to Canada, and the remaining 14 percent largely to other European countries.

Table 3.—U.S. exports of bismuth[1]

Year	Gross weight (pounds)	Value
1966	89,382	$225,617
1967	152,684	395,695
1968	120,466	292,245

[1] Includes bismuth, bismuth alloys, and waste and scrap.

Imports of metallic bismuth declined for the third successive year to 1.27 million pounds, smallest since 1964. The decline reflects a substantial reduction in deliveries of bismuth from Peru which more than offset increased imports from Canada, Mexico, and Japan.

Bismuth alloys were imported from Canada, Mexico, and Peru and amounted to 284,961 pounds of contained bismuth as general imports and 109,877 pounds as imports for consumption. In addition, bismuth compounds containing 3,681 pounds of bismuth were imported from France and the United Kingdom.

International negotiations relating to the General Agreement on Tariff and Trade (GATT) consummated in 1967 revised duties on bismuth, effective on January 1, 1968. The effective duty on bismuth metal was reduced from 1⅞ percent ad valorem to 1 percent in 1968–69, 0.5 percent in 1970, and free thereafter. The duty on bismuth alloys was reduced from 18 percent to 16 percent in 1968 and approximately 2 percent annually thereafter to 9 percent in 1972. The applicable duty on compounds was reduced from 28 percent ad valorem to 25 percent in 1968 and further decreased annually to 14 percent in 1972.

Table 4.—U.S. general imports of metallic bismuth, by countries

Country	1967		1968	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Canada	64,829	$246	121,916	$479
Japan	67,089	264	97,698	371
Korea, South	29,690	116	4,435	17
Mexico	366,211	1,146	383,367	1,316
Netherlands	1,877	(1)	----------	----------
Peru	850,083	3,400	658,260	2,535
Total	1,379,729	5,172	1,265,671	4,718

[1] Less than ½ unit.

WORLD REVIEW

World production of bismuth, excluding withheld data for the United States and several other countries, was 7.6 million pounds, approximately unchanged from that of 1967. Recovery of bismuth as a byproduct from commingled imported ores does not permit full recognition of the mined source and output is credited to the country smelting the ore. Consumption data are largely lacking except for the United States, which is apparently the largest consumer, followed by France, other European countries, and Japan.

Belgium.—Société Generale Metallurgique de Hoboken has scheduled construction during 1969 to enlarge bismuth recovery facilities at their recently expanded lead refinery.

Canada.—The Val d'Or, Quebec, molybdenum-bismuth operation of Molybdenite Corporation of Canada Ltd. was closed to rebuild facilities destroyed in a fire that occurred October 23, 1967. Operations were scheduled to resume in November 1968. Bismuth production continued to be derived from the molybdenum-bismuth mines of Anglo American Molybdenite Mining Corp. and Preissac Molybdenum Mines Ltd., the lead-zinc mines of Cominco and from the copper mine of Gaspé Copper Mines, Ltd.

Japan.—The bismuth-producing companies of Sumitomo Metal Mining Co. Ltd., Mitsui Mining and Smelting Co. Ltd., and Nippon Mining Co. Ltd. were striving to increase output in response to growing demand reportedly reaching about 70 tons per month during August and September.

Table 5.—World production of bismuth, by countries[1]

(Pounds)

Country [2]	1964	1965	1966	1967	1968 [p]
Australia (in concentrate)	----------	----------	716	[e] 132,276	NA
Bolivia	599,365	[r] 598,780	[r] 990,564	1,107,203	[e] 1,235,000
Canada (metal)[3]	399,958	428,759	525,659	668,468	640,000
China, mainland (in ore)[e]	660,000	660,000	660,000	660,000	550,000
France (in ore)	152,100	134,500	129,452	127,867	132,000
Italy (metal)[4]	2,200	8,800	26,500	33,000	NA
Japan (metal)	1,115,611	1,347,183	1,213,513	1,398,565	[e] 1,549,000
Korea, South (metal)	[r] 291,007	[r] 178,573	[r] 216,051	242,506	[e] 216,000
Mexico [3]	[r] 1,102,300	[r] 1,025,139	[r] 1,036,162	1,111,118	[e] 1,146,000
Mozambique	[r] 17,637	[r] 18,228	3,616	4,180	NA
Peru [3]	1,628,514	1,780,503	1,674,261	1,754,033	[e] 1,790,000
South-West Africa (in ore)	3,131	388	4	NA	NA
Spain (metal)	4,184	309	NA	97	NA
Sweden [e]	150,000	77,200	77,200	66,100	NA
U.S.S.R. (metal)[e]	65,000	77,000	77,000	88,000	88,000
United States	W	W	W	W	W
Yugoslavia (metal)	184,660	194,638	228,546	236,928	243,000
Totals [5]	[r] 6,375,667	[r] 6,525,000	[r] 6,859,244	7,630,341	7,589,000

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
W Withheld to avoid disclosing individual company confidential data.

[1] Compiled from data available April 1969.

[2] In addition to countries listed, Argentina, Republic of South Africa and Uganda also produce bismuth in small quantities, and it is believed to be produced in Brazil, Bulgaria, and East Germany but production data for the latter countries are not available.

[3] Bismuth content of refined metal and bullion plus recoverable content of concentrates exported.

[4] Production of Monteponi-Montevecchio Co., probably including production from purchased and toll materials.

[5] Total is of listed figures only.

TECHNOLOGY

Bismuth containing lead-zinc ore samples were included in an investigation of the use of an electron-probe scanning technique to quantitatively delineate rare phases of certain mineralogical associations.[2] In this study the bismuth-bearing fragments occurred in a very irregular distribution suggesting formidable sampling problems.

An article describes examples of unique applications of low melting bismuth alloys for various industrial purposes.[3]

Basic research was reported on the determination of physical properties for bismuth and bismuth-containing materials.[4]

---

[2] Gavrilovic, J., and M. P. Jones. Automatic Searching Unit for the Quantitative Location of Rare Phases by Electron-Probe X-Ray Microanalysis. Trans. Inst. Min. & Met., Sec. B, v. 77, No. 744, November 1968, p. B137.

[3] Darnell, Robert S. Low Melting Bismuth Alloys: Low Cost Problem Solvers. Materials Eng., v. 68, No. 7, December 1968, pp. 30–31.

[4] Cubicciotti, Daniel. Thermodynamic Properties of Bismuth Trifluoride. J. Electrochem. Soc., v. 115, No. 11, November 1968, pp. 1138–1143.

Epstein, S. G. Electromigration of Cadmium and Indium in Liquid Bismuth. Trans. AIME, v. 239, No. 5, May 1967, pp. 627–630.

Frawley, J. J., W. R. Maurer, and W. J. Childs. Vacuum Decanting of Bismuth and Bismuth Alloys. Trans. AIME, v. 242, No. 8, August 1968, pp. 1517–1521.

Giessen, B. C., M. Morris, and N. J. Grant. Metastable Indium-Bismuth Phases Produced by Rapid Quenching. Trans. AIME, v. 239, No. 6, June 1967, pp. 883–889.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/160

Boron

By J. M. West[1]

Output and consumption of boron minerals reached new highs in 1968, continuing an uninterrupted rise from 1961. Supplies to domestic markets were tightened by a labor strike, by processing problems at the major producer's facilities, and also by a general dock strike, which limited imports of borates, mainly Turkish colemanite. Despite these factors, production was essentially at maximum capacity. New uses continued to be found for borates, including a compound for preserving wood; other increasing uses were in glass fiber and laundry products. Further progress was made in developing boron-fiber technology. Rio Tinto Zinc Corp. Ltd. acquired control of United States Borax & Chemical Corp. during the year.

Legislation and Government Programs.—Colemanite from the Government stockpile was being delivered on the basis of a 4-year contract signed in 1967. The purchase covered the entire Government stock.

Table 1.—Salient boron minerals and compounds statistics in the United States

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
Sold or used by producers:					
Quantity:					
Gross weight	776	807	866	955	1,026
Boron oxide	405	425	462	496	543
Value	$60,871	$64,180	$68,209	$74,130	$79,827
Imports for consumption:					
Quantity	(1)	6	12	27	19
Value	$21	$279	$1,034	$1,201	$1,184

[1] Less than ½ unit.

DOMESTIC PRODUCTION

U.S. production of boron minerals rose 7 percent in quantity and 8 percent in value in 1968. Boron minerals were recovered from bedded deposits by open-pit methods in Kern and Inyo Counties, Calif., and from brine solutions at Searles Lake, San Bernardino County, Calif. U.S. Borax & Chemical Corp.'s deposit at Boron in Kern County remained the world's chief source of boron products. The company produced a purified crude borate and various other products at its Boron refinery and a variety of finished products at its Wilmington, Calif., operations, shipping these to many parts of the world. Several expansion projects were underway, including the installation of additional classifiers and replacement of mine haulage equipment at the Boron site. The company also mined a small tonnage of colemanite for the U.S. Atomic Energy Commission from properties in the Furnace Creek area of Inyo County.

The only other producers of borates were American Potash & Chemical Corp. and Stauffer Chemical Co. at Searles Lake, Calif., where borax, potash, soda ash, sodium sulfate, and lithium and bromine salts were among the chief products. A subsidiary of Occidental Petroleum Corp. reportedly acquired property surrounding Searles Lake in preparation for solution mining and open-pond evaporative processing of the brines.

---

[1] Physical scientist, San Francisco Office of Mineral Resources.

CONSUMPTION AND USES

Glass and glass fiber, laundry products, and porcelain enamels were mainly responsible for growth in the use of borates. About half of the total output of boron minerals went into these products, with the balance used for a wide variety of purposes such as flameproofing, mildewproofing, agriculture, leather tanning, metallury, nuclear shielding, adhesives and glues, dental cements, herbicides, cosmetics, and pharmaceuticals.

A borate compound for preserving wood was introduced, and a new boron additive for gasoline was said to reduce engine roughness and increase gasoline mileage by detergent action. Boron carbide was used as a bullet shield in vital parts of military aircraft and in protective vests. Boron filaments and epoxy and other composites were used increasingly in special high-performance products requiring strength, heat-resistance, and light weight. The costs of such materials were expected to fall somewhat as knowledge of fabrication methods improved. The use of borates for fighting forest fires and in sophisticated rocket fuels was generally abandoned because of toxicity.

PRICES

The price of all forms of borax, in bulk quantities rose during the year by $4.50 to $4.75 per short ton or about 5 percent. Boric acid prices rose too, with the sharpest rise for the crystalline product. A $4-per-ton increase was posted in the price of granular boric acid in bags. Other prices remained unchanged.

Table 2.—Borate prices at yearend

	Dollar (per short ton) [1]
Borax, technical:	
Anhydrous, 99 percent:	
Bags	$97.50
Bulk	92.75
Granular, decahydrate, 99.5 percent:	
Bags	54.25
Bulk	50.35
Granular, pentahydrate, 99.5 percent:	
Bags	69.75
Bulk	66.75
Boric acid, technical: [2]	
Anhydrous, 99.9 percent: Bags	325.00
Crystals, 99.9 percent:	
Bags	189.50
Drums	219.50
Granular, 99.9 percent:	
Bags	106.00
Drums	127.00
Bulk	96.00
Sodium borate powder, U.S.P.: Bags	54.00

[1] Carlots f.o.b. plant works.

[2] Boric acid U.S.P. $25 per ton higher than technical grade, in bags.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Exports of boric acid and refined sodium borates totaled 206,823 tons valued at $20.3 million, increases of 11 percent in tonnage and 9 percent in value over those of 1967. Shipments went to more than 34 counties. Of the sodium borates, which comprised 82 percent of the total tonnage, 33 percent went to the Netherlands and 22 percent to Japan. Japan was the leading market for boric acid and bought 32 percent of the total exported. In addition, undetermined quantities of unrefined sodium borates were exported.

Imports of boron compounds and metal in 1968 totaled 19,093 tons valued at $1.18 million. Crude calcium borate (colemanite) from Turkey accounted for 18,959 tons, or 99 percent, of this total, which was valued at $558,140, or only 47 percent of the total value. The United King-

Table 3.—U.S. exports of boric acid and sodium borates, in 1968

Destination	Boric acid (H_3BO_3 content)		Sodium borates (refined)	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	2,140	$252	4,105	$324
Belgium-Luxembourg	--------	------------	540	44
Brazil	1,362	178	3,143	295
Canada	3,664	476	11,967	1,045
Colombia	164	24	1,021	97
Denmark	46	6	217	13
Finland	--------	------------	265	20
France	751	74	959	88
Germany, West	4,699	432	1,973	170
Hong Kong	122	15	2,757	248
Indonesia	6	1	289	18
Israel	33	3	632	53
Italy	107	22	4,751	501
Japan	12,164	1,377	36,923	3,177
Korea, South	148	17	2,098	125
Mexico	1,491	203	8,655	814
Netherlands	5,589	664	55,640	5,886
New Zealand	652	78	3,413	438
Norway	--------	------------	218	15
Pakistan	383	48	1,859	112
Peru	267	32	500	44
Philippines	229	28	840	93
Singapore	10	1	269	19
South Africa, Republic of	286	36	705	69
Spain	97	22	932	96
Sweden	294	28	3,028	258
Switzerland	9	1	2,454	222
Taiwan	193	22	2,055	149
Thailand	83	11	728	63
United Kingdom	2,052	200	7,526	668
Venezuela	237	41	150	18
Vietnam, South	50	6	1,520	91
Yugoslavia	--------	------------	3,925	405
Other	661	98	2,777	273
Total	37,989	4,396	168,834	15,951

dom supplied about 20 tons of crude sodium borate valued at $476 and 203 pounds of other sodium borate valued at $2,190 was also imported. No boric acid was imported during the year. Boron carbide imports totaled 227,486 pounds valued at $575,072, of which 127,220 pounds valued at $381,929 came from West Germany and 99,513 pounds valued at $182,377 came from Canada. Imports of boron metal, waste, and scrap totaled 938 pounds valued at $48,278 and were largely from West Germany.

WORLD REVIEW

Netherlands.—Borax, N. V., the European bulk-handling and storage arm of U.S. Borax & Chemical Corp. and Borax (Holdings) Ltd. expanded its Rotterdam facilities in 1968. Improvements included a new unloading crane, transfer equipment, and more storage space.

Turkey.—Output of boron minerals and chemicals in 1968 totaled 293,100 tons valued at $7.39 million. Development continued at borate deposits of Turk Borax, a subsidiary of Borax Consolidated owned by Borax (Holdings) Ltd. The properties are located in the Kirka area, about 35 miles south of Eskisehir. Discovered in 1963, the deposits, chiefly colemanite, are believed to have reserves of 0.5 to 1 billion tons, mostly minable by open-pit methods. With this and other developments, Turkish colemanite production was expected to expand, limited only by demand. The principal producer of boron minerals remained the public sector firm, Etibank, followed by the private firms, Turk Borax, Rasih ve Ihsan, and Hasmettin Yakal.

Etibank's new borax and boric acid plant at Bandirma was in operation, but the 125,000-ton-per-year sulfuric acid plant, planned as part of the complex, was yet to be constructed. The Turkish Government approved an application by Kemal, a combine of Ugine (France) and American Potash & Chemical Corp., to mine and process colemanite-ulexite ores near Bigadig. Turkey's exports of boron minerals and products in 1967 were valued at $5.84 million, about one-fifth higher than those in 1966. Further gains were expected in 1968.

TECHNOLOGY

A structural beam for aircraft was developed by a division of Boeing Co. utilizing boron-fiber-strengthened epoxy components for their superior stiffness, lightweight, and heat-resistant properties. The experimental work was related to design of the SST prototype. Trailing-edge wing panels for the U.S. Air Force F 111A aircraft were to be fabricated by General Dynamics Corp. using boron fiber tapes. General Electric Co. experimented on boron composites with alloys of titanium, aluminum, and vanadium for high-performance, turbine, aircraft engines.[2] Hamilton Standard Division of United Aircraft Corp. contracted with the U.S. Air Force to supply 3,000 pounds of boron filament at a price of $251 per pound for use in experimental components. The company also marketed a boron filament coated with silicon carbide which can be combined with aluminum to form a tape having unique qualities. A new gasoline additive, detergent boron, was marketed, and the supplier claimed that better performance would result through cleaner engine action.[3]

Scientists at the Oak Ridge, Tenn. laboratories of Union Carbide Corp. continued work on methods for transforming impure amorphous boron into a more dense and pure crystalline form of elemental powder. The Bureau of Mines investigated formation of boron and boron carbide coatings by vapor-phase reactions, and concluded that the strongly adherent and hard coatings so formed could be useful in rocket nozzle applications.[4] The addition of fractional percentages of boron and boron with carbon to electrorefined vanadium was studied, and it was found that an approximate twofold increase in strength was obtained in age-hardening the tested alloys containing both boron and carbon. However, the alloys which had boron additions alone did not age-harden.[5]

Procedures for depositing clear vitreous films of boron nitride on various kinds of substrates were described, and various related physical measurements were given.[6] Potential applications for the process were said to lie in protective coatings on semiconductor surfaces, thin film dielectrics, varistors, and diffusion barriers or sources. In studies of pyrolitic boron nitride used in cryolite and aluminum reduction, it was found that the pyrolitic's rate of corrosion in the melt was only slightly less than the corrosion rate when sintered boron nitride was used.[7] However, although the resistivity of the pyrolitic form did not change appreciably when immersed in the cryolite, that of the sintered grades decreased sharply.

The properties of, and products made from, new boron nitride materials were described in a brochure issued by The Carborundum Company of Niagara Falls, N.Y. Among applications suggested for such materials were uses in heat sinks, insulators, microwave windows, radomes, microcircuit substrates, ion engines, plasma arcs, crucibles, and enclosure of semiconductors. Lockheed Aircraft Corp. used boron nitride to coat boron filament, which, it was found, modified and greatly improved bonding in the formation of aluminum and boron composites.

---

[2] Materials Engineering. Pressed-Foil Composites Tops in Strength Modules. V. 68, No. 3, September 1968, p. 57.

[3] Chemical Week. A New Gasoline Additive Package—Detergent Boron. V. 103, No. 1, July 6, 1968, p. 37.

[4] Donaldson, J. G., James B. Stephenson, and A. A. Cochran. Boron and Boron Carbide by Vapor Deposition. BuMines Rept. of Inv. 7150, 1968, 15 pp.

[5] Iverson, H. G., D. R. Mathews, and J. S. Winston. Effects of Boron and Boron with Carbon on the Mechanical Properties of Vanadium. BuMines Repts. of Inv. 7113, 1968, 18 pp.

[6] Rand, Myron J., and James F. Roberts. Preparation and Properties of Thin Film Boron Nitride. J. Electrochem. Soc., v. 115, No. 4, April 1968, pp. 423–429.

[7] Thonstad, James. The Behavior of Boron Nitride in Molten Cryolite and Aluminum. Electrochem. Technol., v. 6, Nos. 9–10, September–October 1968, pp. 346–349.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 0—344-050/19

Bromine

By Keith S. Olson[1]

An increasing demand for elemental bromine and bromine compounds including ethylene dibromide, ethyl bromide, and methyl bromide resulted in a record output of bromine in 1968. Total output of bromine compounds increased approximately 3 percent in 1968 while production of ethylene dibromide increased about 5 percent. Imports of bromine compounds decreased about 93 percent from those of 1967.

DOMESTIC PRODUCTION

About 362 million pounds of bromine and bromine compounds valued at $86.8 million was produced by eight firms at 12 plants. Michigan was again the major producing State, followed by Texas, Arkansas, and California. The largest increase in production of bromine and bromine compounds occurred in Arkansas, owing chiefly to full production at The Dow Chemical Co.'s new plant in Columbia County and expanded production facilities at plants operated by Arkansas Chemicals, Inc., and Great Lakes Chemical Corp. in Union County. Production in Michigan increased about 1 percent in quantity but decreased about 2 percent in value from that of 1967. Decreases in production of bromine products were recorded in California and Texas. Domestic producers of bromine and bromine products were as follows:

State	Company	County	Plant	Production source
Arkansas	Arkansas Chemicals, Inc.	Union	Arkansas Chemicals	Oil field brines.
	The Dow Chemical Co.	Columbia	Magnolia	Do.
	Great Lakes Chemical Corp.	Union	El Dorado	Do.
	Michigan Chemical Corp.	do	Michigan Chemical Corp.	Do.
California	American Potash & Chemical Corp.	San Bernardino	Trona	Searles Lake brines.
	FMC Corp	Alameda	Newark	Sea water bitterns.
Michigan	The Dow Chemical Co.	Mason	Ludington	Natural well brines.
	Do	Midland	Midland	Do.
	Michigan Chemical Corp.	Manistee	East Lake	Do.
	Do	Gratiot	St. Louis	Do.
	Morton Chemical Co.	Manistee	Manistee	Do.
Texas	Ethyl-Dow Chemical Co.	Brazoria	Ethyl-Dow	Sea water.

Table 1.—Sales of bromine and bromine compounds by primary producers in the United States

(Thousand pounds and thousand dollars)

Year	Quantity		Value
	Gross weight	Bromine content	
1964	283,530	238,019	$66,064
1965	328,115	274,569	77,259
1966	326,498	275,009	78,888
1967	349,757	292,072	85,891
1968	362,452	304,501	86,787

---

[1] Industry economist, Bureau of Mines, Minneapolis, Minn.

Table 2.—Bromine and bromine compounds sold by primary producers in the United States

(Thousand pounds and thousand dollars)

Product	Quantity		Value
	Gross weight	Bromine content	
1967:			
Elemental bromine	48,720	48,720	$10,008
Ethyl bromide	526	385	182
Methyl bromide	18,308	15,414	8,300
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	284,872	230,223	67,328
Total [1]	349,757	292,072	85,391
1968:			
Elemental bromine	51,997	51,997	10,318
Ethyl bromide	569	415	246
Methyl bromide	19,014	16,008	8,001
Other, including ethylene dibromide, sodium bromide, ammonium bromide, and potassium bromide	293,694	238,220	70,041
Total [1]	362,452	304,501	86,787

[1] Total has been adjusted to avoid duplication of transferred or purchased material.

The Bromet Co., a joint venture of Ethyl Corp. (80 percent) and Great Lakes Chemical Corp. (20 percent), began construction of a bromine and ethylene dibromide plant near Magnolia, Ark. Completion of this facility was scheduled for mid-1969. Great Lakes Chemical Corp. was to supervise the design, construction, and operation of the plant located on Ethyl Corp. property. The major portion of Ethyl's bromine requirements were expected to be supplied by this plant.

CONSUMPTION AND USES

About 86 percent of the sales of bromine products by the Nation's primary producers was in the form of bromine compounds. The manufacture of ethylene dibromide consumed a major portion of the domestic bromine output. Elemental bromine ranked second in production of bromine products followed by methyl bromide. Other types of bromine products sold or used included ammonium bromide, ethyl bromide, potassium bromide, and sodium bromide. The major use of ethylene dibromide was in the manufacture of tetra ethyl lead used as an antiknock compound in gasoline. Other uses for bromine and bromine compounds included the manufacture of pharmaceuticals; photographic chemicals; fire extinguisher fluids; fire retardants for plastics, textiles, and other materials; hydraulic and gauge fluids; agricultural chemicals; dyes; intermediates for other chemical processes; sanitizers; and water treatment chemicals. An estimated three out of four fire retardant plastics now contain bromine compounds as the retardant.[2]

PRICES

Quoted prices for bromine and bromine compounds remained firm in 1968. Great Lakes Chemical Corp. and Michigan Chemical Corp. established new pricing plans, based upon geographic zoning, for elemental bromine delivered in tankcar and tank truck lots. Zones established were as follows: Zone I—From Rocky Mountain States east to, and including Ohio, Kentucky, Tennessee, and Alabama. Zone II—Atlantic Seaboard States, plus West Virginia and Pennsylvania. Zone III—Western New York State and upper New England States. The following prices were quoted in the Oil, Paint and Drug Reporter:

---

[2] The Dow Chemical Co. 80 Years of Leadership and Still Pioneering—Bromine and Brominated Compounds. Form No. 164–100–168.

	Cents per pound
Bromine, purified:	
Cases, carlots, ton lots, delivered east of Rocky Mountains	33
Drums, carlots, ton lots, delivered east of Rocky Mountains	29
Zone I:	
Tankcar lots delivered	16.75
Tank truck lots delivered	18.5
Prices in Zone II are 1¢ per pound higher	
Prices in Zone III are 2¢ per pound higher	
Ammonium bromide, National Formulary (N.F.), granular, drums, carlots, ton lots, freight equalized	46
Bromochloromethane:	
Drums, carlots, freight equalized	48
Tanks, same basis	47
Ethyl bromide, 98 percent	
Drums, carlots, freight equalized	68
Ethylene dibromide:	
Drums, carlots, freight equalized	30.5
Tanks, same basis	28.5
Methyl bromide:	
Service organization prices 40 to 375-pound cylinders large lots, freight allowed	57–64
Potassium bromate, 200-pound drums, carlots, freight allowed	49
Potassium bromide, N.F., granular, drums	40
Sodium bromide, N.F., granular, barrels, drums, freight equalized	40

FOREIGN TRADE

Exports of bromine, bromides, and bromates were no longer separately classified, effective January 1, 1965.

In 1968 imports of bromine compounds were 18,687 pounds, compared with 254,560 pounds in 1967. The major reason for the marked decrease was a continuing decline in imports of ethylene dibromide. Increased output of ethylene dibromide by domestic producers in recent years has reduced the demand for imported material.

Imports of bromine compounds reported under existing tariff schedules (TSUS) included 2,116 pounds of ethylene dibromide valued at $371 from Israel and 16,571 pounds of potassium bromide valued at $9,116, of which 10,032 pounds valued at $2,778 was from France, 6,000 pounds valued at $1,676 was from Israel, and 539 pounds valued at $4,662 was from West Germany. No transactions were reported for elemental bromine or sodium bromide. All other classes of bromine compounds are part of a blanket category and are no longer classified separately.

WORLD REVIEW

Botswana (formerly Bechuanaland Protectorate).—Makarikari Soda Ltd., a subsidiary of Botswana RST Ltd., has been investigating the feasibility of commercial development of brines from the Makarikari Salt Pan. These brines contain bromine as well as other minerals.[3] The brine deposit is about 100 feet below the surface and covers about 160 square miles. Ample brine reserves have been proved and can be developed if markets can be found.[4] It is generally believed that commercial extraction of bromine from these brines is dependent upon the production of salt and soda ash.

Israel.—Bromine was recovered from Dead Sea waters, which contain about 1 percent bromine, by the government controlled Dead Sea Works, Ltd. Annual production capacity of the plant is 8,000 metric tons of liquid bromine.[5] Bromine products produced included elemental bromine, ethylene dibromide, and sodium chloride bromine.[6]

Bromine and bromides of saturated acyclic hydrocarbons were among a group of items for which import licenses were granted without restriction, effective September 1, 1968.[7]

---

[3] U.S. Embassy, Gaberones, Botswana. State Department Airgram A-12, Feb. 20, 1969.

[4] Bureau of Mines. Mineral Trade Notes. V. 65, No. 12, December 1968, pp. 32–33.

[5] Bureau of Mines. Mineral Trade Notes. V. 65, No. 7, July 1968, p. 4.

[6] U.S. Embassy, Tel Aviv, Israel. State Department Airgram A557, Feb. 6, 1968, p. 1.

Netherlands.—Plans were announced for a bromine derivatives plant near Woerden to be built by Broomchemie N. V., a joint venture formed by Van Heek Scholco Textielfabrieken N. V. and Eurobroom.[8]

TECHNOLOGY

Tests conducted on cotton fabric treated with flame resistant compounds containing tris (2, 3-diabromopropyl phosphate) were described. Flammability, laundry durability, tear strength, and abrasion resistance of the fabrics were measured.[9]

Three bromine based flame retardants intended primarily for treating textiles and paper were announced. Upholstery fabric treated with one of these compounds was claimed to meet inflammability standards established by the auto industry.[10]

The use of infrared spectrophotometric methods for determining impurities in bromine was described. Recent improvements in bromine quality have necessitated more sensitive and informative methods of analysis.[11]

A patent was issued for a method of producing phosphorous tribromide by the reaction of crude bromine and white phosphorous in phosphorous tribromide as diluent. The reaction occurs at a temperature over 100° C, with the optimum results occurring at 120° to 130° C.[12]

A bromine redox method of desalination was tested on a small pilot plant scale using 40 electrochemical cells at the Los Alamos Scientific Laboratory, Los Alamos, N. Mex. Bromine ranging from 2,300 to 6,000 parts-per-million was used in the feed water as a cathodic depolarizer to minimize power requirements for desalination. Method of preparation, operating procedures, and results were discussed in detail.[13]

---

[7] U.S. Embassy, Tel Aviv, Israel. State Department Airgram A1306, Nov. 18, 1968.

[8] Chemical Age (London). Joint Venture Bromine Derivatives Plant for Holland. V. 99, No. 2587, Feb. 14, 1969, p. 23.

[9] Textile Research Journal. Durable Nonreactive Flame Retardant Finishes for Cotton. V. 38, No. 3, March 1968, pp. 273–279.

[10] Chemical Engineering. Three Flame Retardants. V. 75, No. 18, Aug. 26, 1968, p. 50.

[11] Analytical Chemistry. Determination of Impurities in Bromine by Infrared Spectrophotometric Methods. V. 40, No. 8, July 1968, pp. 1283–1285.

[12] Jenkner, Herbert and Otto Rabe (assigned to Chemische Fabrik Kalk G. m.b. H. Cologne-Kalk, Germany). Method of Producing Phosphorous Tribromide. U.S. Patent 3,409,401, Nov. 5, 1968.

[13] Electro Chemical Technology. Electro Chemical Desalination by a Multistage Bromine Redox Method. V. 6, Nos. 3–4, March-April 1968, pp. 147–150.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/161

Cadmium

By Donald E. Moulds [1]

The cadmium industry accomplished a major recovery in production and consumption in 1968 after the decline registered in 1967. In spite of increased producer shipments, the 15-percent increase in apparent consumption resulted in an industry stock drawdown of some 462,000 pounds of cadmium in metal and compounds combined, increased imports of metal, and an 808,000-pound drawdown of Government stocks. The quoted producer price of $2.65 per pound held steady throughout the year despite the low level of stocks and an indicated premium price in the European market. The strong demand, both domestic and foreign, at yearend indicated a continuing shortfall in supply and upward pressure on price continuing well into 1969.

Legislation and Government Programs.—The cadmium disposal program, conducted by the General Services Administration (GSA), continued throughout the year with a maximum of 600,000 pounds offered for sale during each calendar quarter for domestic consumption only. Shipments from Government inventories amounted to 177,916 pounds in the first quarter, 49,077 pounds in the second quarter, 43,610 pounds in the third quarter, and 536,984 pounds in the fourth quarter, thus totaling 807,587 pounds for the year. At yearend Government stocks totaled 12.94 million pounds, of which 6.04 million was in the strategic stockpile and 6.90 million in the supplemental stockpile. Approximately 7.84 million pounds was considered surplus to the stockpile objective of 5.10 million pounds.

---

[1] Physical scientist, Division of Mineral Studies.

DOMESTIC PRODUCTION

Production of cadmium metal increased 22 percent in relation to the strike-curtailed output during 1967. The labor strike at several cadmium-producing smelters, initiated in mid-1967, continued into April 1968 and was again a factor in the 1968 supply. The total output of 10.7 million pounds was exceeded by shipments amounting to 11.2 million pounds with a corresponding decrease in metal stocks.

Table 1.—Salient cadmium statistics

(Thousand pounds)

	1964	1965	1966	1967	1968
United States:					
Production [1]	10,458	9,671	10,460	8,699	10,651
Shipments by producers [2]	9,689	8,128	11,792	9,606	11,244
Value thousands	$27,412	$19,153	$26,771	$24,665	$28,409
Exports	1,439	73	379	691	530
Imports for consumption, metal	1,104	2,121	3,358	1,587	1,927
Consumption	9,364	10,431	14,780	[r] 11,578	13,328
Price: Average [3] per pound	$3.00	$2.58	$2.42	$2.64	$2.65
World: Production	28,007	26,250	28,665	28,279	31,032

[r] Revised.

[1] Primary and secondary cadmium metal. Includes equivalent metal content of cadmium sponge used directly in production of compounds.

[2] Includes metal consumed at producer plants.

[3] Average quoted price for cadmium sticks and bars in lots of 1 to 5 tons.

Imported flue dust from Mexico contained 1.6 million pounds of cadmium and thus supplied some 15 percent of the domestic output. Over 80 percent of the cadmium produced domestically was recovered as a byproduct from smelting zinc ores derived about equally from domestic and foreign sources. The remainder was of secondary origin derived from reprocessing scrapped cadmium alloys.

The cadmium content of compounds produced in 1968—cadmium sulfide, cadmium lithopone, and cadmium sulfoselenide—totaled 2.5 million pounds, an increase of 60 percent in relation to 1967 and a record high in compound production. Two firms continued to produce cadmium oxide. The output, however, cannot be published.

Cadmium metal was produced at the following plants during the year:

- American Smelting and Refining Company, Denver, Colo., and Corpus Christi, Tex.
- American Zinc Co., East St. Louis, Ill.
- The Anaconda Company, Great Falls, Mont.
- Blackwell Zinc Co., Blackwell, Okla.
- The Bunker Hill Co., Kellogg, Idaho.
- The Eagle-Picher Industries, Inc., Galena, Kans.
- National Zinc Co., Inc., Bartlesville, Okla.
- The New Jersey Zinc Co., Palmerton, Pa.
- St. Joseph Lead Co., Josephtown, Pa.
- United Refining & Smelting Co., Franklin Park, Ill.

Table 2.—Cadmium sulfide[1] produced in the United States

(Thousands pounds)

Year	Sulfide[2]	
	Gross weight	Cadmium content
1964	4,514	1,531
1965	4,666	1,575
1966	5,644	2,267
1967	4,327	1,536
1968	6,003	2,457

[1] Cadmium oxide withheld to avoid disclosing individual company confidential data.

[2] Includes cadmium lithopone and cadmium sulfoselenide.

CONSUMPTION AND USES

Consumption data on cadmium are not gathered by the Bureau of Mines. Apparent commercial consumption of cadmium—production, imports, Government shipments, and known stock changes—was 13.3 million pounds, a 15-percent gain over the 1967 figure but well below the record high of 14.8 million pounds in 1966.

The largest use of cadmium was in the form of metal, estimated to consume some 60 to 70 percent of the total. Plating was the largest application due to the desirability of its high corrosion resistance in parts for automobiles, appliances, aircraft, industrial machinery, hardware, and fasteners. Cadmium-plated titanium fasteners were a growing market in advanced commercial and military aircraft to prevent corrosion failure of the aluminum-titanium junctions. The use of cadmium-nickel rechargeable-sealed batteries as a communications and space power source continued to grow. Cadmium as an additive in various metal alloys also increased.

Cadmium sulfide-based pigments were estimated to account for 12 to 15 percent of the total cadmium consumption. These pigments, in a wide range of colors—yellows, oranges, and reds—depending on the admixture of other elemental sulfides—were used in plastics, paints, enamels, lacquers, and inks.

A wide range of cadmium compounds other than pigments probably accounted for 15 to 20 percent of the cadmium consumed. The use as a vinyl stabilizer was important and growing. Cadmium phosphors were used in television tubes and in coating for fluorescent tubes. Various cadmium salts were used in plating baths and small amounts of high-purity compounds were utilized in solid-state physics applications.

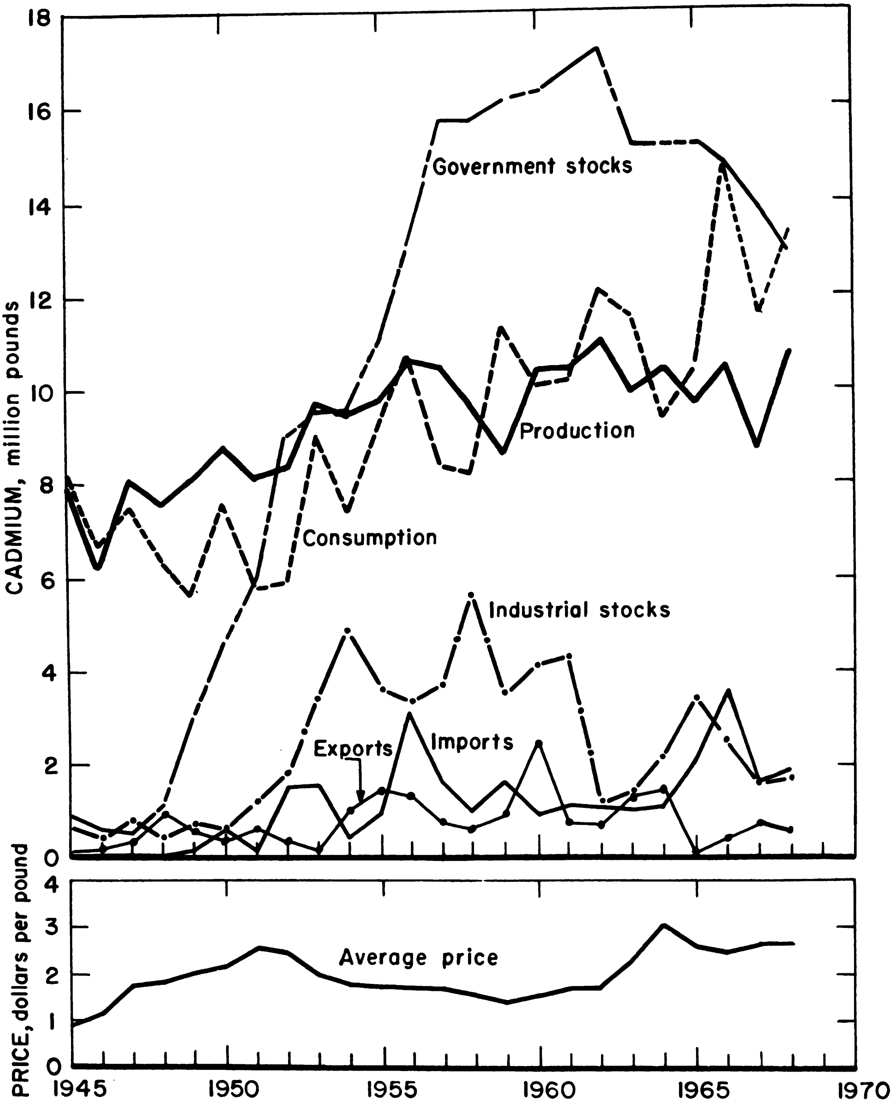

Figure 1.—Trends in production, consumption, yearend stocks, imports, exports, and average price of cadmium metal in the United States.

STOCKS

Total industry stocks of cadmium metal, amounting to 1.5 million pounds at the beginning of the year, were further reduced as the strike continued in the first quarter. With the return to normal production in the second quarter, stocks were built up slightly but heavy demand, both domestic and foreign, reduced metal stocks to about 1.2 million pounds at the end of the third quarter and to 1.1 million at the end of the year, the lowest yearend industry stocks since 1951. It is of note that producer stocks of 3.1 million pounds at the end of 1965 have dwindled to 600,000 pounds of metal in the 3-year period.

Table 3.—Industry stocks, December 31

(Thousand pounds)

	1967		1968	
	Cadmium metal	Cadmium in compounds	Cadmium metal	Cadmium in compounds
Metal producers	921	W	623	W
Compound manufacturers	419	687	232	679
Distributors	r 201	49	214	67
Total	r 1,541	736	1,069	746

r Revised.

W Withheld to avoid disclosing individual company confidential data; included with "Compound manufacturers."

PRICES

The quoted producer to consumer price for cadmium metal in 1-ton lots, effective January 13, 1967, remained at $2.65 per pound throughout the year. Distributor prices, however, were reported at a premium in the first quarter and again in the fourth quarter. The sales price for stockpile metal through GSA continued at $2.53 per pound in ton lots and $2.58 in small lots, f.o.b. storage location. The 12-cent differential for stockpile cadmium is an allowance for conversion to desired consumer shapes.

Cadmium metal on the London Market was 23s per pound ($2.76 per pound, U.S. equivalent) up to August 15 when a range of 23 to 24s developed and subsequently advanced to a range of 26 to 27s. On December 19, the quotation sharply advanced to 35s per pound ($4.20 per pound, U.S. equivalent) and subsequently declined to about $3.50 per pound.

The price in Italy at the beginning of the year was 3,700 lire per kilogram ($2.70 per pound, U.S. equivalent) and held in this area until early October when a gradual advance was initiated to an end of the year price of 4,100 lire ($3.00 per pound). In France, the price of 27.25 francs per kilogram ($2.52 per pound, U.S. equivalent) was in effect until June 19 when an advance to 28.5 francs was posted ($2.64 per pound), and on September 4 a further advance to 30 francs ($2.77 per pound) carried through the yearend.

Table 4.—Prices quoted for cadmium in the United States in 1968

(Per pound)

	Producer to consumer		GSA	
	1-ton lots	Less than 1-ton lots	1-ton lots	Less than 1-ton lots
Jan. 1 to Dec. 31	$2.65	$2.70	$2.53	$2.58

FOREIGN TRADE

Exports of cadmium totaled 530,000 pounds during the year, well below the 691,000 pounds in 1967. Shipments abroad in the first quarter of only 201 pounds reflected the tight domestic supply. An increase to 37,000 pounds in the second quarter was followed by a sharp increase to 314,000 pounds in the third quarter, reflecting the high European demand and premium foreign price. In the fourth quarter, 179,000 pounds was shipped abroad, influenced in part by the strike closure of East Coast ports and the low domestic stock position.

Imports for consumption of cadmium metal increased 21 percent to 1.9 million pounds. Japan was the leading supplier with 668,000 pounds followed by Canada, Australia, Peru, and Mexico. These five countries supplied 95 percent of the total metal. Imports of cadmium in flue dust from Mexico for domestic processing amounted to 1.6 million pounds, well above the 1.2 million pounds reported in 1967.

The import duty on cadmium metal was reduced, effective January 1, 1968, from 3.75 cents per pound to 3 cents per pound in accordance with Presidential Proclamation 3822 and the Kennedy Round trade agreements. Cadmium contained in flue dust remained duty free.

Table 5.—U.S. exports of cadmium metal and cadmium in alloys, dross, flue dust, residues, and scrap

(Thousand pounds and thousand dollars)

Year	Quantity	Value
1966	379	$795
1967	691	1,669
1968	530	1,400

Table 6.—U.S. imports of cadmium metal and cadmium in flue dust, by countries

(Thousand pounds and thousand dollars)

Country	General imports [1]				Imports for consumption [2]			
	1967		1968		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
CADMIUM METAL								
Angola	-----	-------	11	$26	-------	-------	11	$26
Australia	290	$657	297	686	290	$657	297	686
Belgium-Luxembourg	28	68	11	27	28	68	11	27
Canada	538	1,396	508	1,309	538	1,396	508	1,309
Congo (Kinshasa)	22	53	11	26	22	53	11	26
Cyprus	-----	-------	8	19	-------	-------	8	19
Germany, West	(3)	(3)	-------	-------	(3)	(3)	-------	-------
Japan	r 298	r 690	661	1,540	302	696	668	1,555
Mexico	r 181	r 434	152	359	181	434	152	359
Peru	209	472	212	477	209	472	212	477
Poland and Danzig	-----	-------	9	21	-------	-------	9	21
South Africa, Republic of	6	16	40	97	6	16	40	97
Yugoslavia	11	25	-------	-------	11	25	-------	-------
Total	r 1,583	r 3,811	1,920	4,587	1,587	3,817	1,927	4,602
FLUE DUST (CADMIUM CONTENT)								
Mexico	1,166	$1,093	1,605	$1,796	1,166	$1,093	1,605	$1,796
Grand total	r 2,749	r 4,904	3,525	6,383	2,753	4,910	3,532	6,398

r Revised.

[1] Comprises cadmium imported for immediate consumption plus material entering bonded warehouses.

[2] Comprised cadmium imported for immediate consumption plus material withdrawn from bonded warehouses.

[3] Revised to less than ½ unit.

WORLD REVIEW

World production of cadmium was essentially as a byproduct of zinc smelting. Cadmium recovery per ton of slab zinc produced ranged from 1 pound to 20 pounds at the various zinc smelters, dependent upon the cadmium content of the concentrates and other smelting factors. Increased zinc output during the year indicated a world cadmium production in the area of 31 million pounds in comparison with the 28 million pounds in 1967.

A factor in the world supply-demand balance was the withdrawal of U.S.S.R. cadmium from the European market in the second half of the year and, also, curtailment of Japanese exports to the European area. Absence of cadmium from these sources created an upward pressure on price and probable unusual inventory buying. Preliminary consumption statistics from Australia indicated a decrease in total consumption. Those from the United Kingdom showed an increase in consumption of 7 percent, mainly in pigments, plating salts, solder, and miscellaneous uses. Decreased consumption was reported in plating anodes, alloys, and alkaline batteries. Plating consumed 41 percent; pigments 36 percent; alloys, including solder, 10 percent; batteries 7 percent; and miscellaneous 6 percent.

Table 7.—World smelter production of cadmium, by countries[1] [2] [3]

(Thousand pounds)

Country	1964	1965	1966	1967	1968 p e
North America:					
Canada	2,220	r 948	r 1,704	r 2,058	2,094
Mexico	348	152	243	870	410
United States [4]	10,458	9,671	10,460	8,699	10,651
South America: Peru	435	473	442	332	378
Europe:					
Austria	43	46	r 47	42	42
Belgium (exports)	1,857	r 1,620	r 1,282	1,446	1,898
France	1,085	944	988	1,098	1,246
Germany:					
East e	22	22	22	26	26
West	705	723	785	880	754
Italy	611	r 602	540	r 481	540
Netherlands e	231	198	220	r 236	220
Norway	249	r 172	r 159	r 185	198
Poland e	r 937	970	r 948	915	915
Spain	133	137	e 132	e 132	130
U.S.S.R. e	r 3,968	r 4,189	r 4,519	4,850	4,850
United Kingdom [4]	435	485	405	460	490
Yugoslavia e	90	90	90	110	110
Africa:					
Congo (Kinshasa)	363	278	329	e 331	300
South-West Africa	------	73	r 291	e 265	260
Zambia	32	40	27	e 22	20
Asia: Japan	2,678	r 3,262	3,872	4,186	4,500
Oceania: Australia	1,107	r 1,155	1,160	1,155	1,000
Total	28,007	26,250	28,665	28,279	31,032

e Estimate. p Preliminary. r Revised.

[1] Data derived in part from bulletins of the World Metal Statistics (London) and annual issues of Metal Statistics (Metallgesellschaft).

[2] No estimates included for Bulgaria due to lack of information.

[3] Compiled mostly from data available April 1969.

[4] Including secondary.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/162

Calcium and Calcium Compounds

By Benjamin Petkof [1]

Domestic production of natural calcium compounds rose in 1968. Michigan, the major producer of these materials, and California supplied the entire output; West Virginia reported no production during the year. Imports of metallic calcium declined sharply, but calcium chloride imports increased.

DOMESTIC PRODUCTION

Metallic calcium was produced by only one company during the year but no production data were available. The output of all forms of natural and synthetic solid calcium chloride reached 762,000 short tons calculated as 75 percent chloride equivalent. Production of natural and synthetic calcium chloride brine and calcium-magnesium chloride brine (about 40 percent chloride), excluding that used to produce granular forms, reached 566,000 short tons.

Producers of calcium metal, calcium chloride, and calcium-chloride-bearing brines were as follows:

Material and company:	*Location*
Calcium metal:	
Minerals, Pigments and Metals Division of Chas. Pfizer & Co.	Canaan, Conn.
Natural calcium chloride:	
The Dow Chemical Co	Ludington and Midland, Mich.
Michigan Chemical Corp	St. Louis, Mich.
Wyandotte Chemical Corp	Wyandotte, Mich.
Synthetic calcium chloride:	
Industrial Chemical Division, Allied Chemical Corp	Syracuse, N.Y.
PPG Industries, Inc	Barberton, Ohio.
Natural calcium-chloride and calcium magnesium chloride brine:	
Chloride Products, Inc	Niland, Calif.
Imperial Thermal Products, Inc	Do.
Leslie Salt Co. (California Salt Co.)	Amboy, Calif.
National Chloride Company of America	Do.
The Dow Chemical Co	Ludington and Midland, Mich.
Michigan Chemical Corp	St. Louis, Mich.
Morton Chemical Co	Manistee, Mich.
Wilkinson Chemical Corp	Mayville, Mich.
Wyandotte Chemicals Corp	Wyandotte, Mich.
Synthetic calcium chloride and calcium-magnesium chloride brine:	
Industrial Chemical Division, Allied Chemical Corp	Syracuse, N.Y.
PPG Industries, Inc	Barberton, Ohio.
Hooker Chemical Corp	Tacoma, Wash.
Reichhold Chemicals, Inc	Do.

Production of all forms of natural calcium and calcium magnesium chlorides (solid, flake, and liquid), calculated at 75 percent chloride equivalent, averaged 589,000 tons annually for the period 1964–68. The annual average value for the same 5-year period was $12.1 million ($20.55 per ton).

---

[1] Physical scientist, Division of Mineral Studies.

CONSUMPTION AND USES

In metallurgical processing, calcium was used to remove oxygen, halogens, sulfur, and phosphorus from metals that were otherwise difficult to recover as relatively pure products. In the organic chemical industry, calcium was used as a reducing agent and as a dehydrating agent, and in the removal of sulfur from some hydrocarbons. It was used to separate nitrogen from argon. In the form of the hydride it was a valuable portable source of hydrogen which is released when the hydride reacted with water. Organocalcium compounds are used in lubricants, corrosion inhibitors, detergents, and for other purposes.

Highway deicing continued as the major use of calcium chloride. Other important uses included dust control, concrete treatment, industrial uses (including synthetic rubber, paper, and oilfield drilling), brine refrigeration, and tireweighting.

PRICES AND SPECIFICATIONS

Calcium metal prices remained unchange during the year. Commercial-grade metal (99 percent calcium) ranged from $0.95 per pound for full crowns, 2,000 pounds and over, to $3 per pound for less than 100-pound quantities of turnings. Redistilled-grade calcium (99.9 percent calcium and 0.5 percent magnesium) ranged from $1.50 per pound for broken crowns in lots of 6,000 pounds or more to $5 for ⅛-inch nodules in lots of less than 100 pounds. The price of other size lots of broken crowns, ⅛-inch metal and 6-mesh nodules, were between these limits depending on quantity purchased. At yearend almost all categories of calcium chloride showed price increases.

Table 1.—Price quotations for calcium chloride in 1968[1]

Grade	Jan. 1	Dec. 30
Concentrated flake or pellet, 94–97 percent[2]	$44.50	$46.50
Concentrated flake, 77–80 percent[2]	36.25	38.00
Powdered, 77 percent minimum.[2]	42.25	43.28
Liquor, 40 percent[3]	15.00	15.50
Granulated U.S.P.[4]	.29	.29

Source: Oil Paint and Drug Reporter. V. 193, No. 1, Jan. 1, 1968, p. 12; v. 194, No. 27, Dec. 30, 1968, p. 11.

[1] All prices per short ton except granulated which are per pound.

[2] Paper bags, carlots at works, freight equalized.

[3] Tank cars, freight equalized.

[4] 225-pound drums, freight equalized.

FOREIGN TRADE

The quantity of calcium metal imported declined to about 32 percent of the previous year's imports but remained substantially above those of 1966. The average value of imported metal remainded slightly below $1 per pound. All imports of metallic calcium originated in Canada.

Calcium chloride imports increased more than 3 times in quantity and value compared with 1967 imports. The bulk of imported material was supplied by Canada, and Belgium–Luxembourg, smaller quantities were received from the United Kingdom, Sweden, and West Germany.

Other calcium compounds imported during the year were 37.9 million pounds of crude calcium borate valued at $588,000 from Turkey; 13.7 million pounds of calcium carbide valued at $482,000 from Canada and Brazil; 32.3 million pounds of calcium cyanide valued at $1.3 million from Canada; 42.6 million pounds of dicalcium phosphate valued at $1.2 million from Canada, and Belgium–Luxembourg; and 31.8 million pounds of whiting valued $326,000 primarily from France, United Kingdom, and Belgium–Luxembourg. Smaller quantities of other calcium compounds, such as calcium sulphate, calcium carbonate, and calcium hypochlorite, were also imported.

Table 2.—U.S. imports for consumption of calcium and calcium chloride

Year	Calcium		Calcium chloride	
	Pounds	Value	Short tons	Value
1966	85,941	$72,176	2,499	$81,012
1967	428,631	370,407	4,385	157,570
1968	187,251	120,416	14,069	522,680

WORLD REVIEW

Canada.—In addition to the production of magnesium, Dominion Magnesium, Ltd. (Domog), was the only calcium metal producer and supplied three grades of calcium from its Haley Smelter in Ontario. Domog produced a commercial grade containing 98 to 99 percent calcium with impurities of magnesium, nitrogen, and aluminum; a high-purity grade containing 99.5 percent calcium with small impurities such as magnesium, manganese, iron, nitrogen and others; and a chemical grade containing 99.9 percent calcium with impurities similar to those in the high-purity grade.

According to information issued by the Mineral Resources Division of the Department of Energy, Mines and Resources, Canadian production of calcium metal reached 622,237 pounds valued at Can-$591,125 in 1967 an increase of 150 percent in production and 141 percent in value over that of the previous year. About 67 percent of Canadian production was exported to the United States. The major part of the remainder went to France, West Germany, United Kingdom, and Japan.

TECHNOLOGY

A procedure was described for the protection of metal parts by diffusion coating their surfaces in a calcium bath at high temperature. Coatings applied in this manner improved the wear resistance of the original metal surface. Metal thusly prepared could be substituted for stainless steel, stainless clad steel, and other wear resistant metals.[2] An additional paper described the reactions in calcium-iron-chromium systems.[3]

---

[2] Carter, Giles F. Diffusion Coatings Formed in Molten Calcium Impart High Corrosion Resistance. Metal Prog., v. 93, No. 6, June 1968, pp. 117–124.

[3] Carter, G. F., and R. A. Fleming. Diffusion Coatings Formed in Molten Calcium Systems. III. Reactions in Ca-Fe-Cr Systems. J. Less-Common Metals, v. 14, No. 2, February, 1968, pp. 167–179.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/174

Carbon Black

William B. Harper [1]

Shipments of carbon black increased 15 percent in 1968 as a reinvigorated demand followed resumption of work after strikes at rubber plants. Production rose to a new peak.

Use of carbon black by the rubber industry outweighs by far all other uses. In 1968, the use of carbon black in rubber products constituted 94 percent of shipments, and 60 percent of that volume was used by tire manufacturers. Nearly nine out of every 10 tires produced are used on passenger cars, and output, which had been reduced by the 1967 strike, rebounded to 25 percent above 1967 levels and 14.8 percent above the prestrike levels of 1966.

The carbon black industry operated at 84 percent of capacity in 1968, according to preliminary reports. Over the past 5 years, capacity has risen from 7,269,000 pounds to 9,142,000 pounds per day, a net increase of 25.8 percent.

Inventories at the end of 1968 were lower than those a year earlier as shipments of channel blacks exceeded production by 14.7 million pounds. Although overall production of carbon black in 1968 topped that of the preceding year by nearly 328 million pounds, channel black output dropped 6.5 million pounds, thus continuing a downward trend which began in the late 1940's.

The average value of carbon black at the plant in 1968 was 7.32 cents per pound, an increase of 0.15 cent from the levels of a year earlier.

The volume of natural gas used for manufacturing carbon black continued to decline in 1968, but the drop was not as sharp as in 1967, when the volume used dropped along with the reduced demand for carbon black. The use of natural gas in carbon black manufacture was higher in Louisiana by 2.5 billion cubic feet or 9.4 percent above the 1967 levels, but declines in the gas used by plants in Texas and the other States more than offset the gains in Louisiana. Likewise, the cost of natural gas increased in Louisiana but, as indicated

Table 1.—Salient statistics of carbon black produced from natural gas and liquid hydrocarbons in the United States

(Thousand pounds)

	1964	1965	1966	1967	1968
Production:					
Channel process	169,919	147,909	153,117	149,420	142,948
Furnace process	2,053,297	2,205,867	2,418,435	2,334,420	2,668,858
Total	2,223,216	2,353,776	2,571,552	2,483,840	2,811,806
Shipment:					
Domestic sales	1,911,494	2,072,500	2,277,595	2,216,145	2,563,332
Exports	333,907	274,608	297,281	236,035	263,122
Total	2,245,401	2,347,108	2,574,876	2,452,180	2,826,454
Losses	910	135	1,236	559	359
Stocks of producers, December 31	231,171	237,704	233,145	264,247	249,240
Value:					
Production thousand dollars	155,761	166,111	184,308	178,158	205,849
Average per pound cents	7.01	7.06	7.17	7.17	7.32

---

[1] Mineral specialist (petroleum), Division of Mineral Studies.

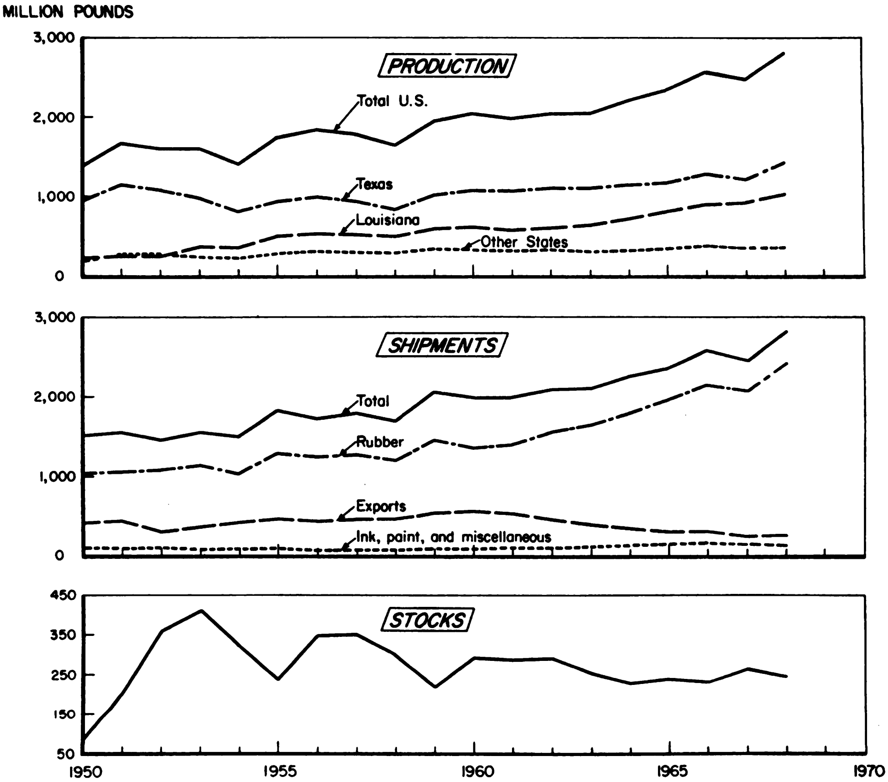

Figure 1.—Production by States, shipments by use, and exports, and stocks of carbon black.

in table 5, that increase was overshadowed by declines in other States.

The amount of liquid hydrocarbons needed to produce furnace blacks in 1968 was higher by 63 million gallons or nearly 15 percent.

Yields of carbon black improved in 1968. Each 1,000 cubic feet of natural gas consumed yielded on the average 5.77 pounds of carbon black as compared with 5.54 pounds per thousand cubic feet in 1967. The yields on carbon black from liquid hydrocarbons, as shown in table 6, were 4.86 pounds per gallon in 1968 as compared with 4.79 pounds in the preceding year. Over the past 10 years, yields have improved moderately from 4.09 pounds to 4.86 pounds per gallon, a difference of 18.8 percent.

PRODUCTION AND CAPACITY

Production by States.—Reflecting a greater demand for carbon black after the rubber plant strikes ended, production of carbon black totaled 2,811.8 million pounds, an increase of 328 million or 13 percent above the depressed levels of 1967. Texas half of the total. Louisiana supplied some produced 1,426 million pounds or about 37 percent or about the same proportion as in 1967. Over the past 5 years (1964–68) Louisiana's share has increased from 32.6 percent of the total to 37.2 percent, while Texas remained at about 50 percent over the same period. Output in the carbon black producing States of Arkansas, Kansas, New Mexico, and Oklahoma, in the aggregate has not expanded over the past 5 years.

Production by Grades and Types.—Although carbon blacks are produced by both channel and the furnace process, the latter accounted for nearly 95 percent of the 1968 total. There are seven major grades of carbon blacks produced by the furnace process, plus thermal blacks. In the furnace category, High Abrasion Furnace or (HAF) grade, constituted the largest single item produced in 1968 and accounted for 30 percent of total furnace blacks. For more than a decade the output of the HAF grade averaged about 30 percent of furnace blacks produced. Production of furnace black, excluding thermal, increased from 1,822 million pounds to 2,364 million pounds between 1964 and 1968. HAF increased from 509 million pounds annually in 1964 to 798 million pounds in 1968, a difference of nearly 57 percent. Second in importance today is the Intermediate Abrasion Furnace (ISAF) grade, which supplied 21 percent of the furnace black. Over the same interval of 1964–68, output of ISAF grade increased from 472 million pounds to 567 million pounds or 20 percent. Trends in the production of blacks by grades are included in table 3.

Production of carbon black from the channel process aggregated 142.9 million pounds or 4.3 percent less than in 1967. Channel blacks are used in inks, pigments, and in mechanical goods, in natural rubber off-the-road tires, in other plies of truck tires and many other nontire applications.

Number and Capacity of Plants.—Expansion of capacities at existing facilities in 1968 primarily were responsible for the increase in daily output of nearly 644,000 pounds or 7.5 percent, as indicated in table 4. There were overall increases of 284,000 pounds daily or 6.6 percent in the capacities of Texas plants. Facilities in Louisiana enlarged their output potential some 218,000 pounds or 7 percent to 3,183,068 pounds daily. Although individual totals cannot be revealed because of disclosure regulations, the capacity of the plants consolidated under "Other States" increased 141,000 pounds per day or 11 percent.

Materials Used and Yields.—Liquid hydrocarbons aggregating 484.4 million gallons were consumed in the manufacture of 2,356.6 million pounds of carbon black, or nearly 84 percent of all the blacks produced. Here again increased use reflects the recovery from the rubber industry strike, as the amount consumed in 1968 was 63 million gallons greater than in 1967. Yields also improved in 1968 with an average of 4.86 pounds per gallon compared with 4.79 pounds in the preceding year. Likewise, yields improved for natural gas. In 1968, while the amount of gas used, was nearly 4 billion cubic feet smaller than in 1967, yields of black were greater; 5.77 pounds compared with 5.54 pounds in 1967.

Table 2.—Carbon black produced from natural gas and liquid hydrocarbons in the United States, by States

(Thousand pounds)

State	1964	1965	1966	1967	1968	Change from 1967 (percent)
Louisiana	725,669	820,552	899,178	923,286	1,031,349	+11.70
Texas	1,165,593	1,172,693	1,296,292	1,214,349	1,426,307	+17.45
Other States	331,954	360,531	376,082	346,205	354,150	+2.29
Total	2,223,216	2,353,776	2,571,552	2,483,840	2,811,806	+13.20

Table 3.—Production of carbon black in the United States, by furnace grades, including thermal and channel black

(Thousand pounds)

Year	SRF [1]	HMF [2]	GPF [3]	FEF [4]	HAF [5]	SAF [6]	ISAF [7]	Thermal	Total	Channel	Grand total
1964	325,921	41,107	188,897	263,558	509,581	20,119	472,423	231,691	2,053,297	169,919	2,223,216
1965	313,602	32,097	198,394	270,908	595,097	18,101	504,331	273,337	2,205,867	147,909	2,353,776
1966	348,730	34,110	213,416	290,773	689,305	20,871	545,631	275,599	2,418,435	153,117	2,571,552
1967	378,457	25,200	155,908	273,812	746,105	17,385	431,439	306,114	2,334,420	149,420	2,483,840
1968 p	(8)	(8)	(8)	[8] 976,367	798,011	22,704	567,163	304,613	2,668,858	142,948	2,811,806

---

p Preliminary.

[1] Semireinforcing furnace.

[2] High-modulus furnace.

[3] General-purpose furnace.

[4] Fast-extrusion furnace.

[5] High-abrasion furnace.

[6] Superabrasion furnace.

[7] Intermediate-abrasion furnace.

[8] Includes SRF, HMF, GPF, FEF grades.

Table 4.—Number and capacity of carbon black plants operated in the United States

State or district	County or Parish	Number of plants 1967 Channel	Number of plants 1967 Furnace	Number of plants 1968 Channel	Number of plants 1968 Furnace	Total daily capacity (pounds) 1967	Total daily capacity (pounds) 1968
Texas	Aransas	—	1	—	1	4,270,900	4,554,941
	Carson	1	—	1	—		
	Ector	1	—	1	—		
	Gaines	1	—	1	—		
	Gray	—	1	—	1		
	Harris	—	1	—	1		
	Howard	—	2	—	2		
	Hutchinson	1	4	1	4		
	Montgomery	—	1	—	1		
	Moore	—	1	—	1		
	Orange	—	1	—	1		
	Terry	—	1	—	1		
	Wheeler	—	1	—	1		
Total Texas		4	14	4	14	4,270,900	4,554,941
Louisiana	Avoyelles	—	1	—	1	2,964,700	3,183,068
	Calcasieu	—	1	—	1		
	Evangeline	—	1	—	1		
	Ouachita	1	2	1	2		
	St. Mary	—	3	—	3		
Total Louisiana		1	8	1	8	2,964,700	3,183,068
Arkansas	Union	—	1	—	1	1,262,600	1,403,849
California	Contra Costa	—	1	—	—		
	Kern	—	2	—	2		
Kansas	Grant	—	1	—	1		
New Mexico	Lea	1	1	1	1		
Oklahoma	Kay	—	1	—	1		
Total		1	7	1	6	1,262,600	1,403,849
Total United States		6	29	6	28	8,498,200	9,141,858

Table 5.—Carbon black and the feedstocks used in its production, by States

	Louisiana	Texas	Other States [1]	Total
1967				
Carbon black production:				
Total thousand pounds	923,286	1,214,349	346,205	2,483,840
Value thousand dollars	61,092	94,565	22,501	178,158
Average value cents per pound	6.62	7.79	6.50	7.17
Natural gas used:[2]				
Total million cubic feet	26,628	61,845	20,488	108,961
Value thousand dollars	4,274	7,765	3,240	15,279
Average value cents per thousand cubic feet	16.05	12.55	15.81	14.02
Carbon black produced [3] thousand pounds	292,518	92,659	80,328	465,505
Liquid hydrocarbons used:				
Total thousand gallons	129,403	240,335	51,548	421,286
Value thousand dollars	9,542	16,872	3,361	29,775
Average value cents per gallon	7.37	7.02	6.52	7.07
Carbon black produced thousand pounds	630,768	1,121,690	265,877	2,018,335
1968				
Carbon black production:				
Total thousand pounds	1,031,349	1,426,307	354,150	2,811,806
Value thousand dollars	70,403	111,091	24,355	205,849
Average value cents per pound	6.83	7.79	6.88	7.32
Natural gas used:[2]				
Total million cubic feet	29,146	59,527	16,300	104,973
Value thousand dollars	4,896	7,367	2,128	14,391
Average value cents per thousand cubic feet	16.80	12.38	13.05	13.71
Carbon black produced [3] thousand pounds	326,019	85,049	44,147	455,215
Liquid hydrocarbons used:				
Total thousand gallons	144,003	282,004	58,397	484,404
Value thousand dollars	10,462	20,056	3,914	34,432
Average value cents per gallon	7.26	7.11	6.70	7.11
Carbon black produced thousand pounds	705,330	1,341,258	310,003	2,356,591

---

[1] Arkansas, California, Kansas, New Mexico, Oklahoma, and West Virginia.
[2] Includes natural gas used to enrich liquid hydrocarbons.
[3] Produced from natural gas used as feedstock.

Table 6.—Natural gas and liquid hydrocarbons used in manufacturing carbon black in the United States and average yield

	1964	1965	1966	1967	1968
Natural gas used [1] million cubic feet	115,626	115,574	114,936	108,961	104,978
Average yield of carbon black per thousand cubic feet [2] pounds	5.38	6.36	5.75	5.54	5.77
Average value of natural gas used per thousand cubic feet cents	13.34	14.59	14.45	14.02	13.71
Liquid hydrocarbons used thousand gallons	354,874	389,173	433,700	421,286	484,404
Average yield of carbon black per gallon pounds	4.65	4.52	4.72	4.79	4.86
Average value of liquid hydrocarbons used per gallon cents	6.79	6.86	7.09	7.07	7.11
Number of producers reporting	9	9	9	9	8
Number of plants	37	34	34	35	34

[1] Includes natural gas used to enrich liquid hydrocarbons.

[2] Average yield based on natural gas used as feedstock, excluding natural gas used to enrich liquid hydrocarbons.

CONSUMPTION AND USES

Demand for carbon black recovered in 1968 after having been reduced by a strike at major rubber producer plants during the spring and summer of 1967. Domestic sales of carbon black increased by 347 million pounds or 15.6 percent. Exports also shared in the gains with a rise of 11.4 percent above the 1967 levels. Domestic sales to the rubber industry, which accounted for 94.4 percent of all the carbon black shipped, were higher by 348 million pounds or 16.8 percent.

Sales gains were made also in the blacks used in ink manufacture, rising nearly 6 percent to 67.7 million pounds. Manufacturers used both the furnace blacks and the channel blacks in their operations. The oil furnace type known as "Short-Ink" was used in the manufacture of inks for printing newspapers. Blacks produced by the channel process known as "Long-Ink" were used in lithographic or halftone printing inks.

The plastics industry expanded its use of carbon black by nearly 6 million pounds or 28.5 percent more than it used in 1967.

Conversely, there has been a decided decline in the use of carbon black by the paper industry. In 1968, for example, shipments dropped nearly 17 percent below 1967 levels as indicated in table 7. Over the longer term, the drop has been even more pronounced; from 8.7 million pounds in 1962 to 4.7 million in 1968, a decrease of 46 percent. Some of this decline can be attributed to technological developments in the paper industry coupled with the development of new products lowering the use of carbon black. Still another consideration, however, is the change in consumer preference from somber tones to brighter colors.

Table 7.—Sales of carbon black for domestic consumption in the United States, by uses

(Thousand pounds)

Use	1964	1965	1966	1967	1968	Change from 1967 (percent)
Ink	45,688	54,333	63,682	63,963	67,721	+5.87
Paint	17,982	10,896	11,959	12,553	13,435	+7.03
Paper	8,004	7,649	6,108	5,658	4,710	−16.76
Plastics	12,281	20,183	21,945	20,907	26,863	+28.49
Rubber	1,789,432	1,945,459	2,131,169	2,072,543	2,420,480	+16.79
Miscellaneous [1]	38,107	33,980	42,732	40,521	30,123	−25.66
Total	1,911,494	2,072,500	2,277,595	2,216,145	2,563,332	+15.67

[1] Chemical and food combined with "Miscellaneous" to avoid disclosing individual company confidential data.

STOCKS

Inventories of carbon black in the aggregate were 15 million pounds lower at the end of 1968 but, as indicated in table 8, virtually all of the drop was in stocks of channel black which were reduced 14.7 million pounds or about 28 percent. Stocks of thermal blacks declined some 3.6 million pounds but supplies of the furnace types were 3.3 million pounds larger at the end of 1968. Most of the rise in stocks of furnace type blacks occurred in the ISAF grade. On the minus side, there were substantial reductions in stocks of SRF grade blacks. SRF along with HMF are furnace blacks generally produced from gas.

Table 8.—Producers' stock of channel- and furnace-type blacks in the United States, December 31

(Thousand pounds)

Year	Furnace									Channel	Grand total
	SRF [1]	HMF [1]	GPF [1]	FEF [1]	HAF [1]	SAF [1]	ISAF [1]	Thermal	Total		
1964	39,200	9,234	26,166	20,641	46,230	5,134	36,062	5,529	188,196	42,975	231,171
1965	34,828	7,291	20,385	23,275	48,644	4,277	35,506	22,835	197,041	40,663	237,704
1966	35,479	5,570	15,709	21,411	53,344	4,925	43,801	9,615	189,854	43,291	233,145
1967	43,747	4,916	13,669	20,029	58,688	6,284	37,951	26,943	212,227	52,020	264,247
1968	([2])	([2])	([2])	[2]76,119	59,786	4,190	48,520	23,327	211,942	37,298	249,240

[1] For explanation, see footnotes to table 3.
[2] Inventories of SRF, HMF, GPF grades included in FEF.

FOREIGN TRADE

A high level of business activity overseas particularly in Europe, the rise in cars in service, coupled with enactment of new standards for tire manufacture in many foreign countries, all have contributed to a rising demand for rubber products and for tires, consequently, the demand for carbon black also has increased. Supplies of carbon blacks in foreign countries have been reduced, so again blacks from the United States are in demand. In 1968, exports rose to 263,122,000 pounds or 11.5 percent above those of the preceding year. Furthermore, 27 percent of exports were blacks made by the channel process. Some channel black is made in West Germany and in Japan but output is insufficient to satisfy demand.

Europe continued to be our best customer accounting for 52 out of every 100 pounds of carbon black exported. Four countries, France, the United Kingdom, Italy, and West Germany aggregate the largest users of carbon black exported from the United States and received 40.8 percent of our exports. In the Western Hemisphere, Canada was the largest user of blacks from the United States. Other exports by countries are given in table 9.

Imports of carbon blacks into the United States are usually limited to specialty blacks and 1968 was no exception. Some 4.9 million pounds of carbon black derived from acetylene were imported from Canada and another 425,000 pounds of the same type black came from East Germany. Colombia supplied nearly 2 million pounds of blacks for pigments; East and West Germany another 250,000 pounds; and the United Kingdom 113,000 pounds for the same purpose.

Table 9.—U.S. exports of carbon black, by countries

(Thousand pounds and thousand dollars)

Country	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
North America:						
Canada	45,243	$3,511	27,591	$2,309	29,189	$2,455
Guatemala	2,479	220	1,423	125	3,042	250
Mexico	2,698	256	1,792	203	4,780	556
Other	209	24	1,534	135	3,085	279
Total	50,629	4,011	32,340	2,772	40,096	3,540
South America:						
Argentina	3,295	352	1,373	218	2,419	300
Brazil	6,321	555	3,190	301	4,800	465
Chile	4,921	464	4,473	426	627	79
Colombia	8,345	757	1,074	117	466	97
Peru	6,087	531	6,317	550	8,731	792
Venezuela	1,527	150	690	77	1,409	133
Other	1,684	154	802	76	844	88
Total	32,180	2,963	17,919	1,760	19,296	1,954
Europe:						
Belgium-Luxembourg	5,471	495	5,366	467	5,804	530
Denmark	969	171	1,110	173	2,135	322
Finland	656	67	595	58	1,044	156
France	39,287	3,979	35,584	3,624	36,523	3,822
Germany, West	35,225	2,809	24,174	2,063	23,871	2,258
Italy	15,862	1,797	17,186	2,048	22,425	2,695
Netherlands	2,890	384	3,185	349	3,793	479
Norway	747	69	959	85	1,145	101
Portugal	2,324	229	1,941	193	709	83
Spain	4,332	470	3,492	438	5,047	602
Sweden	5,089	388	3,335	261	6,075	515
Switzerland	2,784	247	2,140	205	2,504	210
United Kingdom	17,436	2,506	[r] 19,748	[r] 2,839	24,597	3,675
Yugoslavia	632	82	511	63	436	43
Other	4,246	400	3,425	373	855	152
Total	137,950	14,093	[r] 122,751	[r] 13,239	136,963	15,643
Africa:						
South Africa, Republic of	7,877	675	9,338	851	7,736	786
Other	2,140	196	813	77	1,462	125
Total	10,017	871	10,151	928	9,198	911
Asia:						
India	16,117	1,285	6,510	661	3,505	376
Indonesia	665	57	805	60	1,766	148
Iran	3,034	296	364	39	1,150	112
Israel	1,378	143	1,102	112	1,287	117
Japan	6,300	1,248	10,296	1,824	12,093	2,234
Korea, South	7,014	573	7,972	706	11,026	1,041
Philippines	10,150	904	7,340	644	8,737	770
Thailand	3,996	338	4,050	339	2,310	198
Turkey	4,169	349	2,216	199	935	96
Other	4,614	428	3,031	327	3,118	411
Total	57,437	5,621	43,686	4,911	45,927	5,503
Oceania:						
Australia	4,995	474	6,472	554	8,348	773
New Zealand	4,073	374	2,716	246	3,294	302
Total	9,068	848	9,188	800	11,642	1,075
Grand total	297,281	28,407	[r] 236,035	[r] 24,410	263,122	28,626

[r] Revised.

Table 10.—U.S. exports of carbon black in 1968, by months

(Thousand pounds and thousand dollars)

Month	Channel		Furnace		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
January	4,577	$908	15,700	$1,294	20,277	$2,202
February	6,452	1,176	14,715	1,145	21,167	2,321
March	5,335	934	13,698	1,109	19,033	2,043
April	5,316	1,076	16,464	1,296	21,780	2,372
May	5,437	1,136	16,564	1,322	22,001	2,458
June	4,762	833	9,979	818	14,741	1,651
July	5,904	1,109	15,250	1,218	21,154	2,327
August	7,340	1,399	17,684	1,430	25,024	2,829
September	10,358	1,915	20,930	1,715	31,288	3,630
October	3,041	611	11,135	913	14,176	1,524
November	5,024	1,036	20,577	1,700	25,601	2,736
December	7,555	1,055	19,325	1,478	26,880	2,533
Total	71,101	13,188	192,021	15,438	263,122	28,626

WORLD REVIEW

Foreign countries were gradually becoming more self-sufficient in carbon black and a very impressive part of this growth represented expansion programs of U.S. carbon black manufacturers and their affiliates as well as investments by foreign companies.

As indicated in table 11, Japan has almost doubled its production over the last 5 years and very sizable gains were shown in France, West Germany, Italy, the Netherlands, and the United Kingdom. Increased production was also indicated in Rumania, Spain, and Yugoslavia, and Hungary plans to build its first carbon plant in 1970.

Despite these expansions, Western Europe has virtually no facilities producing carbon black either by the channel or the thermal process. Hence, the United States continues to be the principal source of supply for these blacks.

Although data on the magnitude of carbon black facilities in the Soviet Union are lacking, it is not unreasonable to assume that the large supplies of natural gas readily available in that nation offer inducement to make carbon blacks by the channel process as well as furnace blacks from oil and gas.

Table 11.—World production of carbon black by countries[1]

(Thousand pounds)

Country	1964	1965	1966	1967	1968 p
Argentina	25,132	31,967	NA	NA	NA
Brazil	52,699	49,780	64,917	67,681	99,200
France	189,507	220,019	r 265,213	261,906	e 260,143
Germany, West	269,371	276,380	306,943	297,246	e 385,805
India	20,987	31,901	40,000	55,000	55,115
Italy	141,756	162,920	184,450	199,748	198,414
Japan	244,567	r 273,080	297,165	388,742	482,051
Korea, South	694	725	e 882	NA	NA
Netherlands	114,198	136,244	153,881	164,248	169,754
Rumania	78,030	80,918	84,410	115,682	120,973
South Africa, Republic of	26,334	29,020	NA	NA	NA
Spain	r 1,847	r 1,559	7,738	8,360	e 11,023
Taiwan	434	1,404	1,014	1,091	NA
United Kingdom	338,200	353,400	365,500	360,452	403,442
United States	2,223,216	2,353,776	2,571,552	2,483,840	2,811,806
Venezuela	13,499	15,000	16,200	16,204	16,204
Yugoslavia	10,818	11,241	14,462	27,388	e 27,558
Total[2]	r 3,751,289	r 4,029,334	r 4,374,327	r 4,447,583	5,041,488

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Australia, Belgium, Canada, China, Colombia, Mexico, and Sweden produce carbon black, but production data are not available.

[2] Totals are of listed figures only.

TECHNOLOGY

Carbon black, a petrochemical, is an extremely fine soot, primarily carbon (90 to 99 percent) and containing some oxygen and hydrogen; oil furnace blacks may also contain small amounts of sulfur. The furnace process, which accounts for 94 out of every 100 pounds produced, breaks down into three different processes: oil furnace, gas furnace, and thermal. Brief description of the four processes, including the channel process, are as follows:

Channel Black, made by the oldest process, is a product of incomplete combustion of natural gas. Small flames are impinged on cool surfaces or channels where carbon black is deposited and then scraped off as the channel moves back and forth over a scraper. The properties of channel blacks are varied by changes in burner tip design, distances from tip to channel, and the amount of air made available for combustion. The process is extraordinarily inefficient, chemically. For rubber reinforcing grades, the yield is only 5 percent; for finer particle size high color blacks, the yield shrinks to 1 percent. Low yields and rising gas prices have spurred the industry to develop other methods to make blacks.

Gas Furnace.—This is based on partial combustion of natural gas in refractory-lined furnaces. Carbon black is removed by flocculation and high-voltage electric precipitators. Yields of the gas furnace blacks range from 10 to 30 percent and are lowest for the smaller particle size grades. Properties of gas furnace blacks can be modified to a degree by changing the ratio of air to gas. The grades SRF, HMF, and FF are generally produced from gas. (The full name of each grade is given in the footnotes to table 3.)

Thermal.—Unlike channel and furnace blacks, thermal blacks are produced by cracking a hydrocarbon; that is, separating the carbon from the hydrogen and not by the combustion of a hydrocarbon. Thermal furnaces are built from a checkerboard brickwork pattern. Two refractory-lined furnaces or generators are used. One generator is heating, using hydrogen as a fuel, while the other generator is being charged with natural gas which decomposes to produce thermal black and hydrogen. The hydrogen is collected and used to fuel the generator being heated. Yields of carbon black are primarily in the large particle sizes and range from 40 to 50 percent.

Thermal carbon black production has been growing steadily in the United States. The first producer was the Thermatomic Carbon Division of the Commercial Solvents Corp. Then Columbian Carbon Co. and Cabot Corp. began producing thermal blacks. The thermal black facility of J. M. Huber Corp. was scheduled to begin production in 1969.

Relative to thermal type blacks, some progress has been made towards utilizing coal as the raw material for making carbon black.

Commercial manufacturers of carbon black were supplied with samples of the Bureau's product for a determination of its physical and chemical properties and its utility. Rubber manufacturers also identify the end product with thermal black. Subsequently, the Bureau of Mines has made changes in its testing processes and obtained higher yields of carbon of this thermal type black derived from coal.

Oil Furnace.—Here the liquid hydrocarbons are used and the blacks are produced in furnaces. Natural gas is generally burned to furnish the heat of combustion and atomized oil is introduced into this combustion zone to be burned to various grades of carbon black. Yields range from 35 percent to 65 percent depending on the grade of black produced. Oil furnace grades are GPF, FEF, HAF, ISAF, and SAF. (The full name of each grade is given in the footnotes to table 3.)

A most desirable feedstock for furnace black plants is an oil having 0° to 4° API gravity, low in sulfur, and high in aromatics and olefins, which comes from near the "bottom of the refinery barrel" and is similar in many respects to residual fuel oil. The rising cost of natural gas has been a factor in the shift to a greater use of liquid feedstocks and a decline in the use of natural gas as a source of carbon. At the same time, it should be recognized that oil furnace processing has become very flexible. Oil furnace blacks supplemented channel blacks in most high-performance applications, notably passenger car tire treads. Over the past two decades, carbon black technology has centered on the oil furnace black process.

Prior to the 1940's the rubber industry was limited nearly completely to use of the natural rubber. Carbon blacks available for reinforcement were few: (1) channel black, (2) a gas furnace black with semireinforcing properties, and (3) thermal black. Rubber reinforcement grade carbon blacks may be essentially characterized by the two parameters above, particle size and structure level.

Particle size ranges from 200 angstroms for the most highly reinforcing types to about 4,000 angstroms for the slightly reinforcing thermal blacks. Within this relatively narrow dimensional range lie more than two dozen distinct carbon black types used for the reinforcement of rubber.

As to the second parameter, structure level, during formation, the carbon black particles link together in varying degrees as aggregates. The extent to which these aggregates form into reticulate chains has been termed "structure." Carbon blacks vary widely in structure level and this property is second only to particle size with respect to effect on the processing of the various kinds of rubber.

The oil furnace blacks display a higher degree of structure than blacks from natural gas and recent developments have made it possible to vary widely the degree of structure of any grade of oil furnace black. As a result, one of the most important developments has been the increasing use of higher than normal structure carbon blacks for both normal structure ISAF and HAF grades for both tire and nontire applications. The largest single use of carbon black reinforced rubber is in automobile tire treads, where resistance to wear and tear is of utmost importance.

The basic raw materials for carbon black are natural gas and oils; hence, most carbon black producing plants have been located near a fuel and raw material supply in southern Louisiana and in the Texas Panhandle. The carbon black is transported from there to the rubber plants. Recently, however, the carbon black industry has begun to change its policy by building new facilities near the largest customers, the rubber manufactures, not near its fuel supply. The first of these plants built in the East was by The Cabot Corp. at Parkersburg, W. Va., and went on stream early in 1968. The new carbon black plant of the Ashland Chemical Company at Belpre, Ohio, started operations in the fall of 1968. The Phillips Petroleum Co. announced in August 1968 that it planned to build a new carbon black plant at Toledo, Ohio, with completion scheduled for the end of 1969. In the West, the Columbian Carbon Co.'s new plant at Mojave, Calif., to provide blacks for west coast producers of tires and other rubber products is to go on stream in 1969. In the South, the Sid Richardson Carbon Company is building a new plant near Baton Rouge, La., that is scheduled for completion in 1969. Also in the South, the Continental Carbon Company is constructing a new plant at Phoenix City, Ala., to provide carbon black for the rubber industry operating in the Southeast. The new plant is scheduled for completion in early 1970. Summarizing these plants will add to existing capacity of 9,141,858 pounds per day additional facilities to produce another 1,180,000 pounds daily. In 1968, with production at 7,683,530 pounds daily, and capacity at 9,141,858 pounds per day, the industry operated at 84 percent of capacity.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/17

Cement

By John R. Lewis [1]

After the mild retrogression of 1967, portland cement shipments resumed their assault on the coveted 400-million-376 pound barrel goal in 1968. Total portland cement shipments for the year achieved an alltime high of 397 million barrels, and there was every reason to expect that the 400-million-barrel mark would be attained in 1969. This activity reflected vigor throughout the construction sector coupled with continued determined efforts by the cement industry to create new or expanded uses for cement. The industry made progress in balancing its supply and demand factors despite considerable obsolesence of plant and equipment. Profits generally showed improvement but still remained modest and they did not keep up with rising costs. Plant expansions and modernization projects were numerous in 1968, but new plant construction planning was sharply curtailed. Several plants under advanced stages of construction during 1968 will begin operation during 1969. There was no significant change in the industry's production capacity in 1968. Old plants were closed down, but newer ones were often under enlargement or modernization. In 1968 there was just one totally new cement plant which began operation. Numerous expansion projects were completed and one plant was abandoned.

The installation of electronic computer equipment for quality and cost control continued during 1968, and there were further large projects involving new dust-collecting equipment. There were few new distribution terminal projects during the year.

There was cautious optimism that sales would increase during 1969; the continuing boom in the construction industry makes long-term advances in the cement industry near certain. Perhaps forecasting future thrusts of the cement industry was the comment in one annual report that those cement companies which did relatively well in 1968 did so mainly through moves outside of the industry.[2] Diversifica-

Table 1.—Salient cement statistics

	1964	1965	1966	1967	1968
United States:					
Production [1] thousand 376-pound barrels..	377,475	381,578	393,824	377,885	403,349
Capacity used at portland cement mills [1] percent..	76.5	76.8	77.3	72.7	77.6
Shipments from mills [1] thousand 376-pound barrels..	375,340	384,402	389,856	381,824	405,863
Value [1] [2]..................thousands..	$1,209,470	$1,221,454	$1,226,806	$1,210,736	$1,294,533
Average value [1].............per barrel..	$3.22	$3.18	$3.15	$3.17	$3.19
Stocks Dec. 31: at mills [1] thousand 376-pound barrels..	39,761	32,942	40,698	41,529	41,977
Exports..........................do....	713	748	1,069	980	942
Imports for consumption..........do....	3,633	5,505	7,066	5,913	7,370
Consumption, apparent [3].........do....	378,260	389,159	395,853	386,757	412,291
World: Production..................do....	2,437,486	2,543,258	2,722,068	2,831,956	p 2,985,279

[1] Excludes Puerto Rico; includes portland, masonry, and slag cements.
[2] Value received f.o.b. mill, excluding cost of containers.
[3] Quantity shipped plus imports minus exports.

---

[1] Commodity specialist, Division of Mineral Studies.

[2] Alpha Portland Cement Company, Easton, Pa. Annual Report, 1968, p. 3.

tion into related fields, such as other buildings material and residential construction, appeared to be viewed with favor by some units in the industry. Imports of cement were much higher in 1968 and had begun to cause concern on the part of certain domestic producers.

Legislation and Government Programs.—Two legislative measures of interest to the cement industry were signed into law in 1968. The Housing and Urban Development Act (Public Law 90–448) authorized a 3-year program of providing new and rehabilitated housing for low-income families, both urban and nonurban through several separate Federal assistance programs. Thrust of the new housing program will mean vigorous construction activity. Money was also made available through the Department of Housing and Urban Development for many types of public construction activity.

A second important public law was signed on August 3. Titled the Federal Aid Highway Act of 1968, the law extended the 1972 deadline for completion of the Interstate Highway System to 1974 and authorized 1,500 additional miles of road. It also showed greater concern for the environmental factors of highways and directed protection of historic and esthetic values.

Implementation of earlier air pollution laws was emphasized during the year, and the technology of overall air pollution control was studied by the Department of Health, Education and Welfare. Areas around Washington, New York, and Chicago, were named as air quality control regions.

On November 18, 1968, in a memorandum to the heads of departments and agencies of the U.S. Government, President Lyndon B. Johnson urged each department or agency having responsibility for the expenditure of Federal construction funds to take steps to stabilize the levels of construction activity across the entire year in order to reduce seasonal variations and hence assist to increase employment and create price stability in the construction industry. Collaterally, this would reduce seasonal variations in cement consumption. The presidential memorandum cited seven specific actions which were to be taken. These included consideration of local conditions, stretchout of completion dates into the off-seasons, encouragement of any reasonable program among Federal fund recipients to reduce construction seasonality, and where lawful, scheduling construction in off-seasons. Each agency or department concerned was to report steps taken to comply, and to recommend additional remedial measures by July 1, 1969. The Secretaries of Labor and Commerce were further directed to conduct their own special studies and to report their findings and recommendations to the Congress by December 31, 1969.

DOMESTIC PRODUCTION

PORTLAND CEMENT

Total production capability in the U.S. portland cement industry was very nearly stable in 1968 when contrasted to the steady capacity development which had been taking place during recent years. The watchwords in 1968 were "expand existing plants," "close down old or uneconomic plants," and "modernize," all with the aims of reducing costs and increasing efficiency. There was also a marked reduction in new or expanded distribution terminals, probably reflecting the industry's reevaluation and revision of its business structure. A continuing gradual shift to larger plants was evident, as reflected in the following tabulation:

Estimated annual capacity of portland cement plants in the United States (including Puerto Rico) December 31, 1968

Million barrels	Yearend 1966		Yearend 1967		Yearend 1968	
	Number of plants	Percent of total capacity	Number of plants	Percent of total capacity	Number of plants	Percent of total capacity
Less than 1	11	1.7	[1] 11	1.5	6	0.9
1 to 2	60	18.3	[2] 59	17.3	58	17.1
2 to 3	53	25.8	52	24.5	53	25.1
3 to 4	33	22.3	40	26.6	37	23.9
4 to 5	13	11.3	12	10.0	13	10.9
5 and over	14	20.6	14	20.1	16	22.1
Total	184	100.0	188	100.0	183	100.0

[1] Two plants received clinker from other sources.
[2] One plant received clinker from other sources.

Although not a record year for cement facility construction, several major new cement plants were in varying stages of fabrication, but only one plant was completed and ready for commercial production during 1968. This was the 250,000-barrel-per-year white cement plant of the Puerto Rican Cement Co. at Ponce, Puerto Rico. A satisfactory test run was performed in September 1968 and commercial production was expected early in 1969. The new Ponce installation is the first white cement facility in Puerto Rico and the 125,000 barrels normally consumed in the area formerly were imported. The company plans to market the excess throughout the Caribbean and was investigating possible sales in Florida, as well.

The 4-million-barrel, $25 million wet process plant of the Lone Star Cement Corp. at Greencastle, in west central Indiana, neared completion and was expected to be operational during 1969. The plant replaces a 2.7 million-barrel facility at Greencastle, and features computer control at several important stages in the cement-making process.

Northwest of Miami, Fla., the plant of Maule Industries, Inc., was rapidly approaching completion. Built adjacent to the company's quarry at Pennsuco, the plant will utilize two extended kilns and two mills. Slated to begin operation with a capacity of 1.2 million barrels, ultimate plans call for a plant capable of 2.5 million barrels annually. This development reportedly will make Maule Industries self-sufficient in raw materials. The company basically is in the business of producing concrete products.

Martin Marietta Corporation's Rocky Mountain Cement Co. Division made good progress toward 1969 completion of its 2.5-million-barrel plant at Lyons, Colo., near Boulder. Two Martin Marietta subsidiaries, Rocky Mountain and the Dewey Portland Cement Co., Division of Tulsa, Okla., were consolidated as Dewey Rocky Mountain Cement Co. Dewey's 3.1 million-barrel plant and Rocky Mountain's new plant will operate under the new company flag.

Medusa Portland Cement Co. had, by late 1968, virtually completed converting a gray cement plant at Manitowoc, Wis., to a white cement plant. Shipments to customers were scheduled to begin in spring 1969.

During 1968, among the important new plants announced for future construction was Martin Marietta Corporation's Dragon Cement Co. Division replacement plant at Thomaston, Maine. Ground was broken and construction began late in 1968. The 2.5-million-barrel plant, replacing a 2-million-barrel plant which has been in operation at Thomaston since 1927, was expected to be ready in June 1970.

The American Cement Corp. announced plans in mid-1968 for a $25 million plant at Sacramento, Calif. American's Peerless Division also projected a 4-million-barrel plant for the Detroit, Mich., area. Plans called for construction to begin in 1969 and completion by mid-1971. Puerto Rican Cement Co. announced plans in 1968 for its third plant, for completion by 1970. The 2-million-barrel, $13 million plant will be built at Vega Baja, 6 miles from San Juan, and will serve the entire San Juan metropolitan area. It will be, owners said, one of the most modern, automated, computer-controlled plants anywhere in the industry.

Of major interest in 1968 were expansion and modernization projects which were more in the limelight than new plants. While neither record-making in numbers nor in new capacity, they reflected the industry's main thrust during the year.

Lone Star Cement Corp. for instance, completed a build-up in capacity to 4 million barrels during 1968 at its Nazareth, Pa., plant.

Whitehall Cement Manufacturing Co. completed 15 years of steady modernization and expansion at its Cementon, Pa., plant during 1968. All improvement work had proceeded without disrupting plant output.

The Florida Cement Division of General Portland Cement Co., announced plans during 1968 to expand its Miami plant by 50 percent. A new finishing mill was already running by yearend and raw mills and kilns were planned for future installation. Medusa Portland Cement Corp. began work on expanding its 2.5 million barrel Wampum, Pa., plant by 50 percent at a cost of $7 million. At its York, Pa., plant, Medusa started work in 1968 on installation of kiln capacity to balance previously installed grinding capacity. This expansion will elevate the wet process plant output to 2.6 million barrels per year. Startup was targeted for April 1969. At Festus, Mo., River Cement Co. had nearly completed expanding its 3-million-barrel plant to about 5 million barrels. Heart of the project was a 560-foot kiln. Total cost was to be around $11 million.

Lehigh Portland Cement Co. continued to phase out its less economic operations during 1968, to realign its production facilities, and to readjust its distribution patterns. Lehigh's Fordwick, (Shenandoah Valley) Va., plant was closed permanently at yearend. Customers of the 50-year-old, 1.7-million-barrel plant were to be serviced from Lehigh's Union Bridge, Md., plant, for which a $9 million, 33-percent-expansion program to be carried out during 1969–70 was announced in 1968. When completed in 1970, Union Bridge will be capable of producing 5 million barrels annually and the project will be Lehigh's first major expansion since 1961. The American Cement Corp. announced during 1968 that capacity at its Crestmore, Calif., white cement plant would be raised to 1 million barrels.

General Portland Cement Co. announced in 1968, the addition of 2 million barrels of new capacity at its Tampa, Fla., plant. Martin Marietta's Aetna Portland Cement Co., Division put onstream at its Bay City, Mich. plant a kiln and two mills originally intended for the company's abandoned project at Milan, Mich., thus markedly expanding output. At Atlanta, Ga., Martin Marietta's Southern Cement Co. Division was installing a new kiln and two new mills to double that plant's output. At Hudson, N.Y., Universal-Atlas Cement Co. (United States Steel Co. subsidiary) replaced an existing 2-million-barrel plant with new equipment permitting 3 million barrels output. The Ideal Basic Industries, Inc. (formerly Ideal Cement Co.), plant at Superior, Nebr., was stepped up from 1.5 million barrels to 2 million barrels through installation of two kilns and a mill moved from the company's plant at Ada, Okla.

Cancellations of proposed plants and closing of existing plants continued in 1968. Martin Marietta's Aetna Division finally canceled the ill-starred Milan, Mich., plant. Lone Star Cement Corp. canceled plans to build a new plant at Anacortes, Wash., and enlarged its Seattle plant instead. Low profit margins and high expenses caused Lone Star to close down some 7.5 million barrels of capacity at four marginal plants. However, most of the capacity was replaced by modernization at other plants or through other adjusting action. Old, but serviceable, equipment from the Lone Star plant at Hudson, N.Y., was transferred to a subsidiary company plant at Sierras Bayas, Argentina, as was other similar equipment from Lone Star's plant at Lake Charles, La., which was shut down in 1968. Also closed by Lone Star in 1968 was its Dallas, Tex., plant and its Concrete, Wash., facility, equipment from which was later auctioned off.

There was one change in ownership of cement plants in 1968. The Louisville Cement Co., Louisville, Ky., acquired the 4.7-million-barrel plant of the Bessemer Cement Company Division of the Diamond Shamrock Corp. This addition gave Louisville Cement three plants and three distribution terminals.

The Ideal Cement Co. merged, effective the last day of 1967, with Potash Co. of America and in 1968 became known as Ideal Basic Industries, Inc. Nazareth Cement Co. at Nazareth, Pa., was legally merged into Coplay Cement Manufacturing Co., on June 1, 1968, and therefore ceased to exist as a corporate entity. The merger gave the Coplay Co. both plants. During 1968 Ash Grove Lime and Portland Cement Co. of Kansas City, Mo., became Ash Grove Cement Co.

Following the trend toward better air pollution control, at least two companies committed themselves to $2.7 million worth of electrostatic precipitators. Louisville Cement Co. installed units at each of its three plants and Puerto Rican Cement Company began work on a similar installation at its San Juan plant.

NATURAL AND SLAG CEMENTS

Natural cement was produced at one plant, and slag cement was produced at two others. These three plants reported an annual production of about 83,000 barrels. Century Cement Manufacturing Co., Inc. ceased the production of natural cement in 1965.

Because masonry cements prepared at these plants contained some portland cement, they are included in the tabulations of masonry cements prepared at portland cement plants. Production figures are not strictly comparable with those of 1957 and earlier because of changes in the methods of reporting by some of the producers.

TRANSPORTATION

A strike of dockworkers at east and gulf coast seaports began on December 20, 1968. Although some imported cement may have felt the effects, there was no concern by the industry, either with respect to international or coastwise water commerce in cement. Even though the paralyzing and disrupting strike extended into February 1969, cement consumption was at its winter low ebb and markets could easily be covered by other transport means.

Thirty representatives of 26 portland-cement producing companies and a number of representatives of bulk motor carriers met in Chicago, Ill., in June 1968 and organized the National Association of Cement Shippers. The announced purpose is to promote passage and enforcement of laws and regulations affecting the transportation of cement and cement raw materials.

The cement industry continued to utilize the Nation's railroads in 1968 for shipment of cement, both in bulk and in bags. Cement appeared to travel from mill to distribution terminal more by rail than by other transportation means, but exact data were not available. Bulk cement shipments are made in covered hopper bottom cars or in specially constructed rapid-unloading pressure differential cars which unload via a closed system thus eliminating dust, spillage, and contamination. In 1968, at least two sizable fleets of new, covered railroad cars went into service. Dundee Cement Co. added 50 new dry tank cars to its railway fleet for use in moving cement from the main plant to Dundee's customers throughout the center third of the Nation. Each car carries a maximum of 530 barrels of cement. Also in 1968, in connection with construction of the Dworshak Dam in Idaho, some 100 covered hopper cars were ordered for cement hauling service on the Northern Pacific Railway's lines to the dam area.

The *Medusa Challenger,* a Great Lakes iron ore ship converted to the cement trade, was reported in the 1967 yearbook. Her owners, the Medusa Portland Cement Co. of Cleveland, Ohio, reported[3] that, aided by compatible shore installations, the ship set cement handling records during 1968 and exceeded her unloading design expectation of 8,000 barrels of cement per hour. The company also said that the total volume of cement carried was high, and that the ship operated profitably. The ship's self-unloading system and related dockside cement handling systems were recognized by professional engineers as an outstanding accomplishment.

Lone Star Cement Corp. placed a new 3,000-horsepower, $750,000 tug named the *Lone Star* into operation with its gulf coast marine fleet during 1968.[4] The vessel will be used to haul tows of crushed lime rock from the company's quarry at St. Stephens, Ala., to Lone Star's cement plant at New Orleans, La. It can handle a 10,500-ton load at speeds of up to 10 miles per hour and was expected to save $100,000 per year in towing charges.

---

[3] Medusa Portland Cement Co. Cleveland, Ohio. Annual Report, 1968, p. 6.

[4] Lone Star Cement Corp., New York, N.Y. Annual Report, 1968, p. 7.

Although the industry appeared less inclined, in 1968, to install new distribution terminals or to enlarge those already built, there was still activity in this sector. The Peerless Division of the American Cement Corp. opened two new silos with 50,000 barrels of total capacity in a terminal on the banks of the Cuyahoga River at Cleveland, Ohio. The plant is served by rail, water, and truck and utilizes the most advanced of materials handling devices. Operations began in the fall of 1968 at the Auburn, Oreg., terminal of the Oregon Portland Cement Co. Covering 3 acres, the 7,500-barrel main silo was reportedly able to load a bulk cement truck in 5 minutes. A 4,000-barrel multi-compartment silo capable of delivering four types of cement, went into operation in November. A warehouse and sack filling facility were projected for future construction.

General Portland Cement Co. opened three new terminals in 1968—at Jacksonville and Pensacola, Fla., and Statesville, N.C. Lone Star Cement Corp., in widely separated areas, opened a terminal at Portland, Oreg., to serve its customers in that area and another terminal at Andalusia, Ala., to speed cement deliveries in south-central Alabama and northwest Florida.

CONSUMPTION AND USES

After a somewhat disappointing downturn in 1967, consumption of portland cement, as reflected in shipments, rose to an alltime high in 1968. Sparked by the release of pentup demand in public and private construction sectors, the upsurge brought about such events as the record high monthly shipment of cement in October 1968 of 45.4 million barrels.

According to data from the Business and Defense Services Administration, U.S. Department of Commerce, the total value of all new construction "put in place" in 1968 was well ahead of any previous year in the decade. A sharp rise in new construction of all types, including housing and highways, created this unprecedented consumption pattern for cement. Table 2 details the broad pattern of cement consumption and use.

The far-reaching research and development work of the Portland Cement Association continues to create new markets for cement. Prestressed and precast concrete structural members shared an increasing part of the construction market in 1968. Less than 20 years ago there were no prestressed concrete plants in the United States, but by the end of 1968 nearly 300 such plants were in operation and there were about 1,800 plants making masonry blocks in hundreds of shapes and in many different colors.[5]

The advent of color in masonry cements was furthered, for example, in September 1968, when Medusa Portland Cement Co. began production and distribution of "Custom Color" masonry cement from its Dixon, Ill., plant. Medusa's former gray cement plant at York, Pa., converted to the manufacture of white cement during 1968, also distributed the colored line of masonry cements.

As the new generation of super highways continued to expand, demand was developing for heavy concrete median barriers to prevent headon collisions. Widely used and termed successful in New Jersey, some similar type of barrier was in the works for highway uses in 29 other States.

PRICES

The average mill value of a barrel of cement (all classes) remained about $3.17 in 1968.

There were numerous efforts, especially as 1968 began, by individual companies to ask what they termed "more realistic prices for cement." Those who raised prices pointed to increased labor and material costs. Undeniably, cement industry profits were somewhat below those of general industry. Increases ranged from 5 cents per barrel to around 32 cents per barrel for portland cement f.o.b. mill. Averaged out, the upswing was 4.2 percent or about 15 cents per barrel. However, prices did not remain at these levels, and by May generally were back at January levels.

---

[5] Modern Concrete, Cement Uses Set New Highs. V. 32, No. 11, March 1969, pp. 64–66.

Despite the price trends, production costs continued to climb. Coal, for example, was increased in price on October 1. Labor costs rose as the year progressed and it was almost a foregone conclusion that, by May 1969 after labor negotiations, the industry's labor bill would be larger still.

Engineering News-Record provides f.o.b. base prices per barrel for portland cement in carload lots in 20 cities across the Nation. As 1968 closed, price quotations were as follows, with 1967 figure in parentheses:

In bulk, portland cement sold at the 20-city average of $4.09 ($3.99) per ton, and ranged from a high of $4.95 ($4.95) at Pittsburgh, Pa. (Pittsburgh, Pa.), to a low of $3.60 ($3.45) in Detroit, Mich. (New York). In paper bags during 1968, the 20-city average price (carload lots) was $5.13 ($4.77) ranging from a high of $6.88 ($5.65) at New Orleans, La. (Pittsburgh, Pa.), downward to $4.30 ($3.70) in Birmingham, Ala. (New York). Mortar cement selling prices across the country averaged $4.13 ($4.37) per barrel and ranged from a high of $6.40 ($5.20) at New Orleans (both years) to a low of $3.90 ($3.81) at New York. (Atlanta, Ga).

FOREIGN TRADE

Exports of cement from the United States in 1968 totaled 942,000 (376 pound) barrels. French West Indies, took the largest volume, 349,000 barrels valued at $660,000. However, the best U.S. customer in dollar value was Canada, which bought 220,000 barrels valued at $1,117,000. Canada also shipped 1,950,000 barrels to the U.S. in 1968 which were valued at $4,837,000.

Meanwhile, imported cement entering the United States for consumption climbed to an alltime high in 1968, of 7.3 million barrels. Total value was $17,511,000. This is still only 1.8 percent of domestic portland cement shipments, but the trend of recent years is significant. In 1963, total cement imports were 4.0 million barrels, 1.1 percent of domestic shipments. Even earlier, in 1958, total imports for consumption were 3.4 million barrels, which was also 1.1 percent of domestic shipments. Total 1968 cement imports were up 24 percent over those of 1967.

Throughout 1968, the Bahamas, Canada, and Norway provided 90 percent of all imported cement. Bahamian imports were up 25 percent from those of 1967, Canada's were up 16 percent, while Norway's vaulted 85 percent above those a year earlier.

Effective January 1, 1968, Kennedy Round tariff rate reductions went into effect for certain cements imported into the United States. The rate of duty on white cement was lowered from 3 cents per 100 pounds to 2½ cents; the rate for other hydraulic cement and cement clinker went from 2½ cents to 1½ cents per 100 pounds.

WORLD REVIEW

Australia.—Capacity of the relatively new dry process cement plant of Goliath Cement Co., Ltd., at Railton in northern Tasmania, was increased from the original 200,000 tons (1.6 million barrels) per year to 500,000 tons (2.9 million barrels) per year. Estimated cost of the expansion project was A$5 million (US$5.6 million). The company also constructed a fully automated dispatch terminal at Devonport, on Tasmania's north coast. This type of installation is unique in Australia and is said to be one of the most efficient in the world. Cement is transported about 15 miles from the Railton plant to the Devonport terminal in aluminum railroad cars designed and provided by the Tasmanian Government Railways.

Bolivia.—Boliviana de Cemento S.A., La Paz, placed a $2 million order for equipment and services in 1968 for an updating and expansion project at its cement manufacturing facility at Viacha, Bolivia. The order was placed with Allis-Chalmers of Milwaukee, Wis., who supplied kilns to this location in 1930 and who must specially design and engineer the new equipment because of the extreme altitude in which it will operate. The plant site, at 12,800 feet above sea level, is said to be the highest cement-making operation in the world. Present output is about 580 barrels daily. After new equipment is operating the output will be around 1,150 barrels daily or 35,000 barrels per month. Scheduled completion for the expansion is fall 1969.

Brazil.—The country remained very short of necessary cement to complete local, State, and Federal Government work projected and in progress. Construction activity in the private sector also was very high. Allout efforts by the cement industry resulted in a 20-percent increase in cement production for the first half of 1968 compared with production in the same period in 1967. In September, nevertheless, the Governor of the State of São Paulo met with other Government officials and cement manufacturers to announce that it had become necessary for the State Government to import cement because of the short supplies and high prices for the domestic product. A number of using public agencies were requested to look into ways and means of obtaining cement from foreign sources.

Canada.—Canadian cement producers continued their expansion activities during 1968. Typical was the Clarkson, Ontario, wet and dry process plant of the St. Lawrence Cement Co., which completed an expansion and modification program more than doubling capacity and providing comparable gains in economy and processing efficiency. A feature of the program was the installation of North America's largest suspension preheater kiln system plus a related raw materials milling system and high speed bulk truck loadout facilities.

Greece.—The Hellenic Cement Co.'s new $8 million plant at Drepanon, 10 miles east of Petras, went on stream June 26, 1968, with an annual productive capacity of 350,000 tons (1.9 million barrels). The plant manufactures gray portland, high-early-strength, and masonry cement, using indigenous raw materials. It employs about 200 people. Most of its output will go to western mainland Greece and the Peloponnesus. Financing was provided by a $1.5 million loan from the Agency for International Development, a $1.5 million European Investment Bank loan, and local sources. The company's capital stock of $2.8 million is controlled by the Titan Cement Co. of Athens (55 percent), and the American Cement Corp. of Los Angeles (45 percent).

India.—Modernization and expansion of one of India's largest cement plants, the Kalyanpur Lime & Cement Works, Ltd., was completed in 1968. The 38-year-old plant's crushing and grinding systems were redesigned and enlarged. More efficient handling equipment was installed and a new 750-ton-per-day (4,100 barrels) wet process kiln was added. All systems were tied together by modern instrumentation and control circuits. Among other features, the plant's three stationary kilns are direct-fired with pulverized coal produced and processed nearby. The plant has been designed so that electrostatic precipitators can be added later. As completed, the plant has a capacity of 1,200 tons per day (7,000 barrels) or 2.5 million barrels per year. Output for next few years all is slated for construction projects in the Calcutta and New Delhi areas.

Japan.—Japanese cement manufacturing companies totaled 22 in 1968. The three leading firms accounted for more than 10 million tons of annual production capacity (58 million barrels). Latest available information indicates that there were about 55 cement plants in Japan in 1968 which operated a total of around 220 kilns. Total annual capacity was estimated at about 67 million tons (390 million barrels). Japan's cement association expected total demand for fiscal 1968 to be about 45.1 million tons (262 million barrels). Japan ranks third in the world, after the United States and the U.S.S.R., in production of cement.

During the fall of 1968, Tohoku Shipbuilding Co. was building for Kaiser Cement & Gypsum Corp. the first of three vessels for cement hauling service to South Vietnam and related areas.

Morocco.—Cement consumption in Morocco in 1968 rose 16 percent over that in 1967, well above recent average annual increases. Between 1965 and 1967 the increases were about 6.6 percent per year, and in 1964–65 there was a 6.2-percent decrease in cement sales. The good showing of 1968 primarily was attributed to burgeoning hotel construction and to rapidly expanding private housing. A number of dams were also under construction, but for the most part, they were of earth and rock fabrication with only a coating of cement. In all, only 30 percent of cement deliveries were reported as made to projects properly classified as in the public sector. Moroccan construction work consumed 1,015,838 tons (about 5.9 million barrels) in 1968, up from 874,000 tons (about 5.0 million barrels) a year earlier. Nearly all of Morocco's cement comes from five plants in Casablanca, Meknes, Agadir, Tetouan, and Tangier. Only special cements, such as white, are imported. Morocco exported about 10,000 tons (58,000 barrels) in 1968, mostly to the Spanish enclaves of Cueta and Melilla.

Norway.—Late in 1968, three Norwegian cement firms were to merge and become A/S Norcem. The companies were A/S Christiania Portland Cementfabrik, A/S Dalen Portland Cementfabrik, and Nordland Cementfabrik A/S.

Philippines.—An equity interest in the Philippine Rock Products Co. of Manila was purchased during 1968 by the American Cement Corporation of Los Angeles, Calif.

South Africa, Republic of.—Work on the 3,070-foot-long, 280-foot-high Hendrik Verwoerd Dam on the Orange River 100 miles south of Bloemfontein was proceeding on schedule during 1968. Part of a 30-year water conservation project, the dam will be uniquely designed to withstand earthquakes through a basic construction technique using cement tetrahedrons rather than arches and cantilevers. At mid-1968 2,000 cubic yards of cement were being poured per month and the aim for the year was a rate of 70,000 cubic yards per month. A feature of the dam and reservoir will be a 51½-mile-long tunnel which ultimately will be lined with cement ranging from 9 to 20 inches thick.

Spain.—The American Cement Co. of Los Angeles, Calif., through its wholly owned subsidiary, American International Inc., acquired a 50-percent interest in Cementos Portland de Mallorca during 1968. The investment was reported at $2.4 million. American Cement was to have active management responsibility for the Mallorcan company and planned to expand its annual output to over 1 million barrels. The firm enjoys being the only cement company on the Spanish vacation island which lies east of the mainland in the Mediterranean Sea. Mallorca's continued expansion as a tourist mecca has expanded demand for cement.

Swaziland.—The Matola Cement Co. (Swaziland) Limited, subsidiary of a Portugese industrial group, was building a clinker-grinding facility during 1968 in the Matsapa Industrial Estate in Swaziland. Initial production of cement made at this plant was expected to be 30,000 tons (175,000 barrels) which could rise to as much as 100,000 tons (580,000 barrels) within a year. Limestone quarried in Mozambique was to be processed into clinker at limestone burning facilities in Lourenço Marques, using coal shipped in from Swaziland. The clinker will then be shipped to a new clinker grinding facility at Matsapa in Swaziland in iron ore railroad cars or trucks which would otherwise be returning empty to Swaziland.

United Kingdom.—The new $690 million dry process cement plant of the Portland Cement Co. was under construction at Cookstown, near the center of North Ireland, during 1968. Output was planned for September, at a rate of around 1.5 million barrels annually.

TECHNOLOGY

Possibility loomed large in 1968 that the U.S. petroleum industry had finally found a standard, universally usable oil-well cement. Cements manufactured in accordance with the Class H specifications of the American Petroleum Institute were being used successfully on all types of oil-well application all the way from cementing surface casing to downhole work as deep as 22,000 feet. Details of a nationwide survey into the cement's use, conducted by Halliburton Services, a subsidiary of Halliburton Co., were set forth.[6]

The Portland Cement Association's research in the area of rapid-hardening portland cement resulted in development during 1968 of a new formulation which was the basis for a patent application by the Association. Tentatively named "Jet-Set," the new product can be formulated to give any desired setting time from a few minutes to from 1 to 2 hours when used in mortars or concretes. The cement also features a very high early-strength development and concrete made from it appears to have all the desirable properties of normal portland cement concrete. It can be manufactured by a single integral burn or by blending an enriched clinker with regular portland cement clinker.

---

[6] Oil and Gas Journal. Elusive Standard Oil-Well Cement Near. V. 66, No. 26, June 24, 1968, p. 55.

First commercial production run of the new cement was made in December 1968 at the Demopolis, Ala., plant of the Lone Star Cement Corp. This first full-scale production run was for the purpose of determining production costs, seeking clues to possible operating problems and to make a large enough batch for full-scale product testing. Applications chosen for these tests were in road repairs, precast concrete panels, pipe, block, and other promising uses.

There was some indication, throughout 1968, that the so-called Marchon process, which uses byproduct gypsum to manufacture cement and sulfuric acid, was beginning to evoke interest in the Western Hemisphere. Natural gypsum, byproduct gypsum and calcium sulfate byproduct from hydrofluoric acid production as well as anhydrite can all be used as raw material feeds. The Marchon Process is controlled by a British firm, Albright and Wilson, Ltd.

Power-Gas Corp. Ltd., of Britain received world rights to exploit the Marchon process technology early in 1968. Shortly thereafter, Power Gas Corp. of America, a subsidiary, was awarded a contract by the United Gypsum Corp. Ltd. of Vancouver, British Columbia, Canada, to make a feasibility study for a plant to produce sulfuric acid and cement. Location of the proposed plant is Skookumchuck, British Columbia, where United Gypsum holds large reserves of gypsum and anhydrite. Power-Gas was to survey the market potential for both sulfuric acid and cement and make a report encompassing a survey of raw materials, site and mine development, and plant design. Power-Gas of America was also reported to have been engaged to build a Marchon process sulfuric acid-cement plant in Brazil for a specially formed subsidiary of the Chemoleum Corporation called Cimentos e Acidas Limitada (CIASA). The Brazilian plant was to be designed to produce 300,000 tons of sulfuric acid per year and a similar quantity of high-grade cement. No completion date was indicated.

Meanwhile, major South African cement producers were consulting with fertilizer makers concerning the possibilities of recovering sulfur from the byproducts of fertilizer manufacture. Also to come from such processes were possible additional supplies of cement.

Several other processes were described during 1968 as of interest in the United States, sparked primarily by the need for larger supplies of sulfur. The threat to U.S. cement manufacturers of byproduct cement, and the processes involved, were covered in two articles published during the year.[7]

The 10th Cement Industry Technical Conference sponsored by the Institute of Electrical and Electronics Engineers (IEEE) was held in May at St. Louis, Mo.[8] Interest in the conference was worldwide, with 13 percent of registrants coming from foreign-based concerns. Seventeen technical papers were presented, grouped under five general topical headings: General practices and process equipment, power distribution, maintenance and safety, drives, and automation.

Cement specifications from standards organizations in 44 countries are included in a new reference book published in English in 1968 by CEMBUREAU, the European Cement Association in Paris. In addition to standards for portland cement, the various types of blast furnace and pozzolanic cements have been included. In addition to a wealth of other detail, a special section lists the names and addresses of national standards organizations throughout the world.[9]

The American Society for Testing and Materials (ASTM) issued a book (cost—$4.00) during 1968 covering some of the major problems of portland cement formulation, both from the point of view of manufacturing techniques and from the demands of published standards. Control and significance of consistency, air entrainment, and bleeding are discussed. The collection also covers the differences between ASTM, American Association of State Highway Officials, and Federal specifications for portland cement and the consideration a manufacturer must give to these differences.[10]

---

[7] Messman, Henry C. By-product Cement New Threat to U.S. Portland Cement Industry. Miner. Proc., v. 9, No. 10, October 1968, pp. 14, 15.
Minerals Processing. European Process for Cement/Sulfuric Acid Production Comes to the United States. V. 9, No. 11, November 1968, pp. 14, 15.

[8] Pit and Quarry. IEEE Sponsors Tenth Annual Cement Industry Technical Conference. V. 61, No. 1, July 1968, pp. 72–76, & 183–184.

[9] The European Cement Association. Cement Standards of the World—Portland Cement and its Derivatives. CEMBUREAU, Paris, France, 1968, 252 pp.

An article by J. C. Witt, consulting engineer, discusses the application of colored and white cements in building, noting that improved quality and reduced plant costs are enabling both types of cement to compete successfully with other construction materials.[11]

---

[10] American Society for Testing and Materials, 1916 Race Street, Philadelphia, Penn. 19103.

[11] Witt, J. C. The Wonderful World of Color. Rock Products, v. 71, No. 7, July 1968, pp. 83, 104, 106.

Table 2.—Finished portland cement produced, shipped, and in stock in the United States,[1] by districts

District	Active plants		Production (thousand 376-pound barrels)		Shipments from mills						Stocks at mills Dec. 31 (thousand 376-pound barrels)	
					1967			1968				
					Thousand 376-pound barrels	Value		Thousand 376-pound barrels	Value			
	1967	1968	1967	1968		Total (thousands)	Average per barrel		Total (thousands)	Average per barrel	1967	1968
New York, Maine	13	11	26,684	28,696	28,816	$75,780	$2.63	29,090	$75,006	$2.58	3,535	3,472
Eastern Pennsylvania	17	17	28,957	32,145	29,596	81,704	2.76	31,270	86,569	2.77	2,906	3,704
Western Pennsylvania	5	5	10,453	11,784	10,601	32,888	3.10	11,748	36,608	3.12	1,716	1,844
Maryland, West Virginia	4	4	9,675	10,591	10,160	30,509	3.00	10,151	30,330	2.99	662	972
Ohio	9	9	14,773	14,891	14,726	46,860	3.18	15,222	49,814	3.27	2,224	1,766
Michigan	9	9	29,862	31,195	29,645	94,515	3.19	31,375	99,158	3.16	3,825	4,043
Indiana, Kentucky, Wisconsin	8	7	20,966	19,148	21,061	69,478	3.30	18,265	59,341	3.25	2,184	2,309
Illinois	4	4	9,608	9,719	9,069	30,186	3.33	9,372	32,475	3.47	1,811	1,829
Tennessee	5	6	7,947	8,584	8,062	25,548	3.17	8,488	27,691	3.26	955	943
Virginia, North Carolina, South Carolina	6	6	12,560	12,515	12,835	38,698	3.02	12,584	39,537	3.14	1,041	930
Georgia, Florida	6	6	11,608	13,163	11,593	38,348	3.31	13,883	45,254	3.26	787	753
Alabama	8	8	13,445	13,291	15,364	46,510	3.03	15,514	48,147	3.10	1,529	1,386
Louisiana, Mississippi	6	6	8,943	8,394	9,158	29,033	3.17	8,719	28,487	3.27	816	500
Minnesota, South Dakota, Nebraska	4	4	6,512	7,195	6,535	21,990	3.36	6,885	23,907	3.47	1,007	1,330
Iowa	5	5	13,650	13,544	13,712	45,394	3.31	13,900	47,275	3.40	1,526	1,343
Missouri	8	8	14,888	19,806	15,044	52,119	3.46	20,081	71,206	3.55	2,539	2,656
Kansas	6	6	9,023	9,887	8,833	25,545	2.89	9,680	29,898	3.09	1,403	1,585
Oklahoma, Arkansas	5	5	12,370	12,587	12,014	35,954	2.99	12,237	35,995	2.94	1,362	1,378
Texas	19	20	32,277	34,161	31,944	99,329	3.11	34,499	107,532	3.12	3,157	2,722
Wyoming, Montana, Idaho	4	4	3,485	3,818	3,356	11,548	3.44	3,881	13,669	3.52	792	735
Colorado, Arizona, Utah, New Mexico	7	7	10,974	12,099	10,885	37,664	3.46	12,105	42,141	3.48	1,287	1,281
Washington	7	5	5,884	6,327	5,614	20,581	3.67	6,328	23,030	3.64	799	925
Oregon, Nevada	4	3	3,393	3,617	3,518	12,707	3.61	3,812	13,657	3.58	265	201
Northern California	6	6	17,877	18,426	17,822	61,109	3.43	18,967	61,682	3.25	1,418	1,446
Southern California	8	8	24,178	28,650	24,212	76,851	3.17	28,628	90,279	3.15	1,745	1,780
Hawaii	2	2	1,444	1,752	1,395	7,360	5.28	1,841	9,254	5.03	217	130
Puerto Rico	2	2	7,963	8,924	8,447	27,397	3.24	8,923	27,577	3.09	151	152
Total	188	183	369,399	394,909	374,017	1,175,605	3.14	397,448	1,255,519	3.16	41,659	42,115

[1] Includes Puerto Rico.

Table 3.—Portland cement produced and shipped by plants in the United States,[1] by types

Type and year	Active plants	Production (thousand 376-pound barrels)	Shipments		
			Thousand 376-pound barrels	Value	
				Total (thousands)	Average per barrel
General use and moderate heat (types I and II):					
1964	181	[2] 347,954	346,052	$1,090,712	$3.15
1965	181	[2] 348,665	352,431	1,095,639	3.11
1966	[3] 183	[2] 359,493	358,446	1,102,940	3.08
1967	[4] 186	[2] 346,577	352,254	1,091,956	3.10
1968	[3] 180	[2] 370,358	373,668	1,164,594	3.12
High-early-strength (type III):					
1964	144	[5] 12,873	12,530	44,124	3.52
1965	153	[5] 13,388	12,757	44,621	3.50
1966	149	[5] 14,550	12,955	44,828	3.46
1967	145	[5] 12,899	12,188	42,453	3.48
1968	145	[5] 13,519	12,980	44,853	3.46
Low-heat (type IV):					
1964	1	(6)	(6)	(6)	-------
1965	-----	---------	---------	-----------	-------
1966	-----	---------	---------	-----------	-------
1967	-----	---------	---------	-----------	-------
1968	-----	---------	---------	-----------	-------
Sulfate-resisting (type V):					
1964	16	446	398	1,443	3.63
1965	19	512	425	1,648	3.88
1966	18	540	482	1,796	3.73
1967	18	870	560	2,023	3.61
1968	21	1,630	1,437	4,957	3.45
Oil-well:					
1964	12	1,347	1,306	4,329	3.31
1965	13	1,645	1,613	5,571	3.45
1966	14	2,172	2,006	6,954	3.47
1967	14	2,518	2,413	9,251	3.83
1968	14	2,502	2,596	9,512	3.66
White:					
1964	5	[7] 2,139	2,111	14,821	7.02
1965	5	[7] 2,241	2,128	14,517	6.82
1966	5	[7] 2,208	2,060	14,675	7.12
1967	6	[7] 2,244	2,092	13,928	6.66
1968	6	[7] 2,242	2,200	15,159	6.89
Portland-slag and portland pozzolan:					
1964	10	[8] 1,047	1,057	3,656	3.46
1965	6	[8] 967	913	2,878	3.15
1966	[3] 5	[8] 956	562	1,732	3.08
1967	[3] 6	[8] 818	780	2,610	3.35
1968	5	[8] 444	454	1,607	3.54
Miscellaneous:[9]					
1964	22	[10] 2,827	2,850	9,902	3.47
1965	34	[10] 4,004	3,819	12,989	3.40
1966	39	[10] 4,713	4,183	14,336	3.43
1967	32	[10] 3,473	3,730	13,384	3.59
1968	43	[10] 4,214	4,113	14,837	3.61
Grand total:					
1964	[11] 181	368,633	366,304	1,168,987	3.19
1965	[11] 181	371,422	374,086	1,177,863	3.15
1966	[4] [11] 184	384,632	380,694	1,187,261	3.12
1967	[11] [12] 188	369,399	374,017	1,175,605	3.14
1968	[4] [11] 183	394,909	397,448	1,255,519	3.16

[r] Revised.

[1] Includes Puerto Rico.

[2] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1964, 43,950; 1965, 46,118; 1966, 46,022; 1967, 43,801; 1968, 40,608.

[3] Includes one plant which received clinker from another source.

[4] Includes two plants which received clinker from other sources.

[5] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1964, 2,754; 1965, 2,677; 1966, 2,611; 1967, 2,218; 1968, 2,049.

[6] Less than ½ unit.

[7] Includes a small quantity of air-entrained portland cement.

[8] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1964, 343; 1965, none; 1966, 392; 1967, 167; 1968, 60.

[9] Includes hydroplastic, plastic, and waterproofed cements.

[10] Includes air-entrained portland cement as follows (in thousand 376-pound barrels): 1964, 367; 1965, 775; 1966, 853; 1967, 434; 1968, 528.

[11] Includes number of plants making air-entrained portland cement as follows: 1964, 130; 1965, 132; 1966, 129; 1967, 132; 1968, 125.

[12] Includes three plants which received clinker from other sources.

Table 4.—Shipments of prepared masonry cement from mills in the United States, by States

(Thousand 280-pound barrels)

Destination	1967	1968
Alabama	633	648
Alaska [1]	W	W
Arizona	W	W
Arkansas	335	359
Colorado	183	198
Connecticut [1]	145	144
Delaware [1]	55	57
District of Columbia [1]	275	249
Florida	1,287	1,438
Georgia	1,189	1,393
Idaho	11	11
Illinois	730	795
Indiana	808	845
Iowa	217	195
Kansas	162	185
Kentucky	575	632
Louisiana	428	480
Maine	75	84
Maryland	642	686
Massachusetts [1]	265	312
Michigan	1,474	1,433
Minnesota	419	455
Mississippi	374	393
Missouri	214	235
Montana	18	15
Nebraska	74	79
Nevada	W	W
New Hampshire [1]	70	78
New Jersey	612	623
New Mexico	76	78
New York	940	898
North Carolina	1,490	1,558
North Dakota [1]	57	48
Ohio	1,404	1,581
Oklahoma	267	290
Oregon	1	2
Eastern Pennsylvania	452	460
Western Pennsylvania	616	646
Rhode Island [1]	29	29
South Carolina	884	934
South Dakota	51	50
Tennessee	1,139	1,189
Texas	856	1,000
Utah	5	6
Vermont [1]	43	45
Virginia	1,161	1,296
Washington	52	61
West Virginia	240	246
Wisconsin	482	486
Wyoming	11	14
Total United States	21,526	22,939
Other countries [2]	174	228
Total shipped from cement plants	21,700	23,167

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."

[1] No cement producer.

[2] Direct shipments by producers to other countries and to Alaska, Arizona, and Nevada.

Table 5.—Prepared masonry cement produced and shipped in the United States, by districts

District	Active plants		Production (thousand 280-pound barrels)		Shipments from mills					
					1967			1968		
	1967	1968	1967	1968	Thousand 280-pound barrels	Value (thousands)	Average per barrel	Thousand 280-pound barrels	Value (thousands)	Average per barrel
New York, Maine	9	8	937	988	994	$2,284	$2.30	930	$2,172	$2.34
Eastern Pennsylvania	11	11	1,978	2,217	1,930	5,048	2.62	2,026	5,368	2.65
Western Pennsylvania	5	5	1,013	1,116	999	2,901	2.90	1,125	3,344	2.97
Maryland, West Virginia	5	5	880	937	876	2,104	2.40	882	2,314	2.62
Ohio	7	6	925	1,019	946	2,731	2.89	1,063	3,155	2.97
Michigan	5	5	1,989	2,128	1,995	5,296	2.65	2,006	5,527	2.76
Indiana, Kentucky, Wisconsin	6	6	3,033	3,213	3,012	9,184	3.05	3,209	8,491	2.65
Illinois	4	3	595	634	591	1,851	3.13	602	2,097	3.48
Tennessee	5	4	1,047	1,386	1,092	2,992	2.74	1,370	3,836	2.80
Virginia, North Carolina, South Carolina	7	6	1,951	2,072	1,905	5,904	3.10	2,087	6,312	3.02
Georgia, Florida	4	3	1,026	1,011	1,046	2,918	2.79	1,006	2,839	2.82
Alabama	9	9	2,503	2,348	2,377	6,938	2.92	2,523	7,309	2.90
Louisiana, Mississippi	5	5	517	402	441	1,142	2.59	474	1,238	2.61
Minnesota, South Dakota, Nebraska	4	4	256	279	246	829	3.37	250	865	3.46
Iowa	4	4	634	615	612	1,853	3.03	624	1,986	3.18
Missouri	6	5	487	354	371	1,172	3.16	405	1,312	3.24
Kansas	7	7	331	360	350	1,000	2.86	383	1,177	3.07
Oklahoma, Arkansas	5	5	549	548	532	1,593	2.99	568	1,712	3.01
Texas	13	13	867	997	888	2,847	3.21	1,059	3,371	3.18
Wyoming, Montana, Idaho	3	3	27	47	24	79	3.29	38	121	3.18
Colorado, Arizona, Utah, New Mexico	[r] 5	5	401	467	407	1,295	3.18	480	1,538	3.20
Washington	5	4	65	63	65	200	3.08	56	175	3.13
Oregon, Nevada	----	----	-----	-----	1	7	7.00	1	5	5.00
Total	[r] 134	126	21,961	23,201	21,700	62,168	2.86	23,167	66,259	2.86

[r] Revised.

Table 6.—Natural, slag, and hydraulic-lime cements produced, shipped, and in stock at mills in the United States

Year	Production		Shipments		Stocks Dec. 31 (thousand 376-pound barrels)
	Active plants	Thousand 376-pound barrels	Thousand 376-pound barrels	Value (thousands)	
1964	4	275	283	$1,057	76
1965	4	279	279	1,027	76
1966	3	113	109	415	19
1967	3	95	94	360	21
1968	3	86	86	332	14

Table 7.—Portland-cement-manufacturing capacity of the United States,[1] by districts

District	Capacity Dec. 31 (thousand 376-pound barrels)[2]		Percent utilized	
	1967	1968	1967	1968
New York, Maine	37,225	34,192	71.7	83.9
Eastern Pennsylvania	37,194	37,392	77.9	86.0
Western Pennsylvania	13,740	13,847	76.1	85.1
Maryland, West Virginia	12,650	12,650	76.5	83.7
Ohio	19,749	19,744	74.8	75.4
Michigan	39,162	39,162	76.2	79.7
Indiana, Kentucky, Wisconsin	24,700	23,193	84.9	82.6
Illinois	11,600	11,600	82.8	83.8
Tennessee	10,156	10,156	78.2	84.5
Virginia, North Carolina, South Carolina	16,900	16,900	74.3	74.1
Georgia, Florida	17,381	18,856	66.8	69.8
Alabama	16,660	16,611	80.7	80.8
Louisiana, Mississippi	11,400	11,200	78.4	74.9
Minnesota, South Dakota, Nebraska	9,117	9,099	71.4	79.1
Iowa	15,462	15,462	88.3	87.6
Missouri	27,210	29,296	54.7	67.6
Kansas	12,822	12,855	70.4	76.9
Oklahoma, Arkansas	15,400	15,500	80.3	81.2
Texas	46,199	47,793	69.9	71.5
Wyoming, Montana, Idaho	5,100	5,100	68.3	74.9
Colorado, Arizona, Utah, New Mexico	16,650	16,800	65.9	72.0
Washington	9,575	8,200	61.5	77.2
Oregon, Nevada	6,400	5,700	58.0	63.5
Northern California	21,700	21,700	82.4	84.9
Southern California	40,600	42,600	59.6	67.3
Hawaii	2,700	2,700	53.5	64.9
Puerto Rico	11,500	10,750	69.2	83.0
Total	508,952	509,058	72.6	77.6

[1] Includes Puerto Rico.

[2] These capacities are estimates and/or approximations only, based upon the best information available from the companies operating each plant, but should not be taken as absolute values.

Table 8.—Capacity of finished portland cement plants in the United States,[1] by processes

Process	Capacity, Dec. 31 [2]				Percent of capacity utilized		Percent of total finished cement produced	
	Thousand 376-pound barrels		Percent of total					
	1967	1968	1967	1968	1967	1968	1967	1968
Wet	313,735	314,432	61.6	61.8	71.6	76.2	60.8	60.7
Dry	195,217	194,626	38.4	38.2	74.1	79.8	39.2	39.3
Total	508,952	509,058	100.0	100.0	72.6	77.6	100.0	100.0

[1] Includes Puerto Rico.

[2] These capacities are estimates and/or approximations only, based upon the best information available from the companies operating each plant, but should not be taken as absolute values.

Table 9.—Portland cement clinker produced and in stock at mills in the United States,[1] by process

Clinker	Number of plants [2]		Thousand 376-pound barrels			
			Production		Stocks on Dec. 31—	
	1967	1968	1967	1968	1967	1968
Wet	116	115	230,906	243,391	10,899	11,654
Dry	72	68	147,670	154,630	11,916	10,880
Total	188	183	378,576	398,021	22,815	22,534

[1] Includes Puerto Rico.

[2] Three plants received clinker from other sources (1967); two plants (1968).

Table 10.—Production and percentage of total output of portland cement in the United States,[1] by raw materials used

(Quantities in thousand 376-pound barrels)

Year	Cement rock and pure limestone		Limestone and clay or shale [2] [3]		Blast-furnace slag and limestone	
	Quantity	Percent	Quantity	Percent	Quantity	Percent
1964	85,884	23.3	260,376	70.6	22,373	6.1
1965	84,360	22.7	266,148	71.7	20,914	5.6
1966	86,095	22.4	277,597	72.2	20,940	5.4
1967	[r] 72,231	[r] 19.5	281,704	76.3	[r] 15,464	[r] 4.2
1968	77,556	19.6	304,861	77.2	12,492	3.2

[r] Revised.
[1] Includes Puerto Rico.
[2] Includes output of plants using marl and clay; 2 plants in 1964, 1965, 1966, and 1967; 1 plant in 1968.
[3] Includes output of plants using oystershell and clay; 11 plants in 1965, 1966, and 1967; 12 plants in 1964 and 1968.

Table 11.—Raw materials used in producing portland cement in the United States[1]

(Thousand short tons)

Raw materials	1966	1967	1968
Cement rock	21,072	21,544	23,842
Limestone (including oystershell)	84,068	80,013	83,751
Marl	762	716	701
Clay and shale [2]	11,545	11,574	12,489
Blast-furnace slag	1,132	1,058	1,086
Gypsum	3,280	3,264	3,427
Sand and sandstone (including silica and quartz)	1,920	1,467	1,807
Iron materials [3]	714	658	652
Miscellaneous [4]	288	225	431
Total	124,781	120,519	128,186

[1] Includes Puerto Rico.
[2] Includes fuller's earth, diaspore, and kaolin.
[3] Includes iron ore, pyrite cinders and ore, and mill scale.
[4] Includes fluorspar, punicite, calcium chloride, soda ash, borax, staurolite, fly ash, bauxite, diatomite, air-entraining compounds, and grinding aids.

Table 12.—Finished portland cement produced and fuel consumed by the portland-cement industry in the United States,[1] by processes

Year and process	Finished cement produced			Fuel consumed		
	Plants	Thousand 376-pound barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1967:						
Wet	117	223,327	60.5	5,258	4,365	138,923,356
Dry	71	146,072	39.5	3,838	591	56,794,140
Total	188	369,399	100.0	[2] 9,096	4,956	195,717,496
1968:						
Wet	114	239,572	60.7	5,551	4,987	140,486,474
Dry	69	155,337	39.3	3,957	775	62,484,980
Total	183	394,909	100.0	[3] 9,508	5,762	202,921,454

[1] Includes Puerto Rico.
[2] Comprises 238,809 tons of anthracite and 8,857,445 tons of bituminous coal.
[3] Comprises 180,631 tons of anthracite and 9,327,170 tons of bituminous coal.

Table 13.—Portland cement produced in the United States,[1] by kinds of fuel

Year and fuel	Finished cement produced			Fuel consumed		
	Plants	Thousand 376-pound barrels	Percent of total	Coal (thousand short tons)	Oil (thousand 42-gallon barrels)	Natural gas (thousand cubic feet)
1967:						
Coal	63	[2] 126,255	34.2	6,168	--------	-------------
Oil	7	[2] 15,531	4.2	--------	3,406	-------------
Natural gas	45	[2] 73,530	19.9	--------	--------	89,704,241
Coal and oil	18	37,428	10.1	1,628	[r] 964	-------------
Coal and natural gas	25	47,735	12.9	1,187	--------	33,391,828
Oil and natural gas	22	55,091	15.0	--------	554	57,558,770
Coal, oil, and natural gas	8	13,829	3.7	113	32	15,062,657
Total	188	369,399	100.0	[3] 9,096	4,956	195,717,496
1968:						
Coal	60	[2] 132,741	33.6	6,381	--------	-------------
Oil	7	[2] 16,948	4.3	--------	3,320	-------------
Natural gas	48	[2] 91,956	23.3	--------	--------	107,305,858
Coal and oil	18	41,373	10.5	1,772	1,140	-------------
Coal and natural gas	24	48,013	12.1	1,187	--------	32,585,007
Oil and natural gas	19	48,172	12.2	--------	1,162	47,883,961
Coal, oil, and natural gas	7	15,706	4.0	168	140	15,146,628
Total	183	394,909	100.0	[4] 9,508	5,762	202,921,454

[r] Revised.

[1] Includes Puerto Rico.

[2] Average consumption of fuel per barrel of cement produced as follows: 1967—coal, 97.7 pounds; oil, 0.2193 barrel; natural gas, 1,220 cubic feet; 1968—coal, 96.1 pounds; oil, 0.19589 barrels; natural gas, 1.167 cubic feet.

[3] Comprises 238,809 tons of anthracite and 8,857,441 tons of bituminous coal.

[4] Comprises 180,631 tons of anthracite and 9,327,170 tons of bituminous coal.

Table 14.—Electric energy used at portland cement plants in the United States,[1] by processes

Year and process	Electric energy used						Finished cement produced (thousand 376-pound barrels)	Average electric energy used per barrel of cement produced (kilowatt-hours)
	Generated at portland cement plants		Purchased		Total			
	Active plants	Million kilowatt-hours	Active plants	Million kilowatt-hours	Million kilowatt-hours	Percent		
1967:								
Wet	15	344	113	5,038	5,382	58.8	224,752	23.9
Dry	16	872	72	2,902	3,774	41.2	144,647	26.0
Total	31	1,216	185	7,940	9,156	100.0	369,399	24.7
Percent of total electric energy used	-------	13.3	-------	86.7	100.0	-------	-------	-------
1968:								
Wet	11	337	109	5,284	5,621	58.7	239,572	23.4
Dry	15	873	68	3,075	3,948	41.3	155,337	25.4
Total	26	1,210	177	8,359	9,569	100.0	394,909	24.2
Percent of total electric energy used	-------	12.6	-------	87.4	100.0	-------	-------	-------

[1] Includes Puerto Rico.

Table 15.—Shipments of portland cement from mills in the United States,[1] in bulk and in containers by types of carriers

Year and type of carrier	In bulk		In paper bags [2]		Total shipments	
	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent	Thousand 376-pound barrels	Percent
1967:						
Truck	233,651	69.3	29,092	78.8	262,743	70.3
Railroad	96,350	28.6	7,264	19.7	103,614	27.7
Boat	7,012	2.1	572	1.5	7,584	2.0
Used at the plant	71	-------	5	-------	76	-------
Total	337,084	100.0	36,933	100.0	374,017	100.0
Percent of total	90.1	-------	9.9	-------	100.0	-------
1968:						
Truck	252,565	70.4	31,722	82.3	284,287	71.5
Railroad	94,654	26.4	6,538	17.0	101,192	25.5
Boat	11,650	3.2	267	.7	11,917	3.0
Used at the plant	50	-------	2	-------	52	-------
Total	358,919	100.0	38,529	100.0	397,448	100.0
Percent of total	90.3	-------	9.7	-------	100.0	-------

[1] Includes Puerto Rico.

[2] Cloth bags and other containers included with paper bags to avoid disclosing individual company confidential data.

Table 16.—Cement shipments by types of customers in 1968

(Quantities in thousand 376-pound barrels)

District	Number of plants in district	Building material dealers		Concrete product manufacturers		Ready-mixed concrete		Highway contractors		Other contractors		Federal, State and other Government agencies		Miscellaneous including own use		Total
		Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	
New York, Maine	11	5.8	1,697	11.5	3,334	61.1	17,770	4.0	1,167	2.1	617	----	6	15.5	4,499	29,090
Eastern Pennsylvania	17	10.9	3,408	22.8	7,128	58.7	18,369	5.9	1,838	.7	215	0.2	61	.8	256	31,270
Western Pennsylvania	5	7.1	840	12.9	1,515	62.4	7,330	11.2	1,314	4.3	505	----	------	2.1	244	11,748
Maryland, West Virginia	4	4.1	413	21.8	2,218	63.6	6,453	8.3	840	1.5	150	.5	55	.2	22	10,151
Ohio	9	5.0	754	17.0	2,581	61.0	9,284	14.4	2,203	1.8	279	.1	17	.7	104	15,222
Michigan	9	7.0	2,191	15.5	4,882	61.9	19,409	12.2	3,822	2.9	919	----	------	.5	152	31,375
Indiana, Kentucky, Wisconsin	7	5.3	967	13.6	2,477	63.4	11,590	15.0	2,742	2.0	362	.2	31	.5	96	18,265
Illinois	4	5.4	502	7.4	693	77.9	7,303	8.0	748	1.2	113	.1	13	----	------	9,372
Tennessee	6	6.0	512	19.6	1,665	66.0	5,598	3.7	309	2.9	248	.5	42	1.3	114	8,488
Virginia, North Carolina, South Carolina	6	10.1	1,270	16.8	2,120	57.8	7,273	11.6	1,455	1.5	191	2.1	260	.1	15	12,584
Georgia, Florida	6	14.5	2,016	19.2	2,661	51.1	7,098	7.9	1,095	6.0	832	.7	102	.6	79	13,883
Alabama	8	5.7	887	14.9	2,313	60.5	9,386	11.8	1,833	5.1	784	1.4	211	.6	100	15,514
Louisiana, Mississippi	6	9.9	867	17.4	1,515	44.9	3,912	13.3	1,163	10.8	940	.5	46	3.2	276	8,719
Minnesota, South Dakota, Nebraska	4	8.6	589	10.0	685	54.4	3,749	24.5	1,688	1.5	104	.2	14	.8	56	6,885
Iowa	5	4.8	665	16.8	2,335	64.6	8,989	9.9	1,374	3.6	499	.2	27	.1	11	13,900
Missouri	8	3.4	687	8.4	1,688	69.8	14,017	14.7	2,947	2.6	511	.2	45	.9	186	20,081
Kansas	6	6.1	588	11.8	1,139	55.6	5,384	16.6	1,609	4.6	446	.7	68	4.6	446	9,680
Oklahoma, Arkansas	5	9.4	1,154	6.8	827	57.6	7,043	16.2	1,985	8.3	1,017	----	5	1.7	206	12,237
Texas	20	7.1	2,438	7.6	2,631	55.9	19,281	8.5	2,931	6.3	2,188	1.0	344	13.6	4,686	34,499
Wyoming, Montana, Idaho	4	6.7	262	10.3	399	56.7	2,199	5.1	198	16.8	652	----	(1)	4.4	171	3,881
Colorado, Arizona, Utah, New Mexico	7	7.8	945	9.8	1,185	65.9	7,977	6.8	829	6.6	795	.6	74	2.5	300	12,105
Washington	5	3.7	237	10.6	668	69.9	4,424	7.1	451	3.9	245	3.9	249	.9	54	6,328
Oregon, Nevada	3	3.8	145	7.4	281	71.7	2,731	9.9	379	7.0	268	.1	5	.1	3	3,812
Northern California	6	5.3	1,005	8.5	1,617	64.4	12,207	4.8	909	15.9	3,014	.2	35	.9	180	18,967
Southern California	8	6.0	1,730	11.4	3,274	64.2	18,376	7.8	2,233	7.2	2,056	1.5	428	1.9	531	28,628
Hawaii	2	6.1	112	14.4	264	74.4	1,370	1.9	35	2.1	39	1.0	19	.1	2	1,841
Puerto Rico	2	56.8	5,064	4.6	413	26.7	2,381	----	------	.7	64	----	3	11.2	998	8,923
Total	183	8.0	31,940	13.2	52,508	60.6	240,903	9.6	38,097	4.6	18,053	.5	2,160	3.5	13,787	397,448

[1] Less than ½ unit.

Table 17.—Destination of shipments of all types of finished portland and high-early-strength cement from mills in the United States, by States

(Thousand 376-pound barrels)

Destination	Finished portland		High-early-strength	
	1967	1968	1967	1968
Alabama	5,631	6,178	81	82
Alaska [1]	W	W	W	W
Arizona	3,579	4,440	W	W
Arkansas	4,436	4,437	31	13
Northern California	16,490	17,788	23	36
Southern California	21,700	26,848	146	226
Colorado	4,591	4,936	37	17
Connecticut [1]	3,701	4,313	299	329
Delaware [1]	1,126	1,010	59	44
District of Columbia [1]	1,295	1,427	27	16
Flordia	14,524	16,292	887	975
Georgia	9,354	9,734	202	237
Hawaii	1,341	1,885	--------	--------
Idaho	1,130	1,730	55	60
Illinois	19,060	20,885	578	566
Indiana	10,699	10,213	381	373
Iowa	9,035	8,096	84	97
Kansas	4,755	5,729	72	57
Kentucky	5,983	7,250	126	131
Louisiana	11,773	12,545	42	122
Maine	987	1,017	46	59
Maryland	6,722	6,438	336	318
Massachusetts [1]	6,063	6,547	459	478
Michigan	16,386	16,158	858	920
Minnesota	8,366	8,764	241	395
Mississippi	4,224	4,371	14	12
Missouri	9,355	9,709	200	229
Montana	1,092	1,483	13	16
Nebraska	4,396	4,370	153	158
Nevada	1,164	1,350	7	5
New Hampshire [1]	916	1,037	59	78
New Jersey [1]	9,855	10,319	497	466
New Mexico	2,351	2,851	121	121
New York	17,544	17,691	961	1,005
North Carolina [1]	7,477	7,383	276	301
North Dakota [1]	934	922	29	48
Ohio	18,484	20,013	400	487
Oklahoma	5,258	6,045	38	58
Oregon	3,415	3,622	104	100
Eastern Pennsylvania	10,707	11,164	478	449
Western Pennsylvania	6,819	7,301	218	218
Rhode Island [1]	1,221	1,091	113	128
South Carolina	3,932	4,041	112	182
South Dakota	1,199	1,543	54	67
Tennessee	6,770	7,230	196	206
Texas	26,955	28,356	1,504	1,498
Utah	1,891	2,053	45	49
Vermont [1]	641	723	48	61
Virginia	8,314	8,921	346	403
Washington	7,368	6,686	631	652
West Virginia	2,305	2,597	33	34
Wisconsin	10,000	8,967	366	349
Wyoming	985	978	10	5
Total United States	364,299	387,472	12,096	12,916
Other countries	[2] 9,718	[2] 9,976	[3] 92	[3] 64
Total shipped from cement plants	374,017	397,448	12,188	12,980

W Withheld to avoid disclosing individual company confidential data; included with "Other countries."

[1] Noncement producer.

[2] Direct shipments by producers to foreign countries, the State of Alaska, and to Puerto Rico, including distribution from Puerto Rican mills.

[3] Direct shipments by producers to other countries and the States of Alaska and Arizona.

Table 18.—Average mill value in bulk, of cement in the United States[1]

(Per barrel)

Year	Portland cement [2]	Natural slag, and hydraulic-lime cements [2]	Prepared masonry cement [3] [4]	All classes of cement [5]
1964	$3.19	$3.73	$2.83	$3.22
1965	3.15	3.68	2.84	3.18
1966	3.12	3.74	2.83	3.15
1967	3.14	3.87	2.86	3.17
1968	3.16	3.86	2.86	3.19

[1] Includes Puerto Rico.
[2] 376-pound barrels.
[3] Includes masonry cements made at portland, natural, and slag cement plants.
[4] 280-pound barrels.
[5] Includes masonry cement converted to 376-pound barrels.

Table 19.—U.S. exports of hydraulic cement by countries

(Thousand 376-pound barrels and thousand dollars)

Destination	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	7	$30	9	$73	9	$56
Bahamas	33	166	45	233	44	217
Belgium-Luxembourg	1	32	1	20	7	55
Bolivia	4	39	4	34	4	42
Canada	495	2,130	349	1,426	222	1,117
Chile	7	53	2	28	3	40
Dominican Republic	1	9	6	25	3	17
France	5	20	5	21	1	10
French West Indies	160	347	210	509	349	660
Germany, West	3	28	1	31	4	80
Indonesia	(1)	4	6	60	16	149
Iran	14	108	5	40	1	5
Italy	2	24	3	23	2	16
Jamaica	3	41	5	28	5	28
Japan	6	127	8	155	11	197
Leeward and Windward Islands	64	180	104	273	130	271
Liberia	34	128	5	22	1	4
Mexico	120	504	37	260	17	197
Netherlands	4	18	1	8	2	10
Netherlands Antilles	4	9	29	75	42	87
Nicaragua	3	14	3	17	10	67
Nigeria	6	25	67	463	(1)	4
Norway	3	13	4	16	3	12
Pakistan	1	6	1	5	(1)	1
Panama	2	27	3	20	1	16
Peru	10	70	15	103	6	42
Philippines	8	88	8	52	3	29
Spain	8	114	7	49	3	14
Sweden	3	14	1	16	1	22
Taiwan	3	38	2	26	1	20
Trinidad and Tobago	1	3	4	83	(1)	2
United Kingdom	3	19	2	8	5	28
Venezuela	3	21	2	13	2	27
Vietnam, South	3	17	2	10	(1)	1
Western Africa, n.e.c.	9	39	3	28	4	33
Other	36	331	21	199	30	308
Total	1,069	4,836	980	4,452	942	3,884

[1] Less than ½ unit.

Table 20.—U.S. imports for consumption of cement

(Thousand 376-pound barrels and thousand dollars)

Year	Roman, portland, and other hydraulic cement		Hydraulic cement clinker		White nonstaining portland cement		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1966	6,211	$15,000	648	$1,847	207	$996	7,066	$17,846
1967	[r] 5,591	[r] 13,058	[r] 135	[r] 757	187	883	5,913	14,698
1968	7,003	16,236	152	242	215	1,033	7,370	17,511

[r] Revised.

Table 21.—U.S. imports for consumption of hydraulic cement in 1968, by countries and customs districts

(Thousand 376-pound barrels and thousand dollars)

	Quantity	Value
Country:		
Bahamas	3,076	$7,301
Belgium-Luxembourg	129	605
Canada	1,950	4,837
Colombia	406	849
Denmark	24	125
France	1	3
Germany, West	18	185
Japan	52	219
Mexico	3	16
Netherlands	(1)	1
Norway	1,665	3,055
Spain	1	5
United Kingdom	22	159
Venezuela	1	2
Yugoslavia	22	149
Total	7,370	17,511
Customs district:		
Anchorage	22	190
Bridgeport	570	944
Buffalo	1,630	3,546
Detroit	1	3
Great Falls	19	67
Honolulu	2	14
Customs district—Continued:		
Houston	2	$14
Laredo	3	16
Los Angeles	16	73
Miami	993	2,459
Milwaukee	(1)	(1)
Minneapolis	(1)	(1)
Mobile	91	97
New Orleans	4	17
New York	1,458	2,999
Norfolk	444	1,042
Ogdensburg	59	218
Pembina	159	616
Philadelphia	38	316
Portland, Maine	16	64
Portland, Oregon	3	23
Providence	(1)	(1)
St. Albans	25	104
San Francisco	(1)	2
San Juan	539	1,490
Savannah	10	71
Seattle	25	73
Tampa	1,241	3,053
Total	7,370	17,511

[1] Less than ½ unit.

Table 22.—World production of hydraulic cement, by countries

(Thousand 376-pound barrels)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Bahamas	---------	NA	NA	23,440	• 23,400
Canada (sold or used by producers)	42,075	44,432	[r] 47,478	42,503	44,015
Costa Rica	193	698	674	651	774
Cuba •	4,726	4,697	4,691	5,251	NA
Dominican Republic	1,747	1,243	1,618	1,817	1,922
El Salvador	528	475	833	838	900
Guatemala	1,091	1,378	1,184	1,313	1,055
Haiti	328	246	223	234	240
Honduras	428	551	616	651	756
Jamaica	1,624	1,823	2,052	1,963	2,403
Mexico	25,904	25,286	28,871	32,798	35,898
Nicaragua	358	387	493	563	598
Panama	733	973	879	NA	NA
Trinidad and Tobago	1,032	1,114	1,243	1,118	1,218
United States (including Puerto Rico)	385,386	388,847	401,771	385,629	397,343
South America:					
Argentina	[r] 17,070	19,378	[r] 20,416	20,809	24,524
Bolivia	[r] 381	352	[r] 381	363	416
Brazil	32,975	[r] 32,957	35,450	37,533	42,667
Chile	7,429	[r] 6,962	7,998	7,237	7,381
Colombia	[r] 11,515	[r] 12,031	[r] 12,154	12,388	13,871
Ecuador	1,689	1,906	[r] 2,215	• 2,285	2,525
Paraguay	135	170	152	82	141
Peru	4,767	5,963	[1] 6,268	6,106	6,375
Uruguay	[r] 2,356	[r] 2,479	[r] 2,748	2,438	3,018
Venezudla	10,847	12,383	12,395	13,173	14,287
Europe:					
Albania	745	879	[r] 815	1,295	1,289
Austria	22,099	2,3711	26,391	26,651	26,681
Belgium	34,277	34,623	33,984	34,105	34,800
Bulgaria	[r] 15,154	15,720	16,746	19,678	• 19,924
Czechoslovakia	32,207	33,497	35,942	37,856	37,600
Denmark	11,129	11,700	12,300	12,892	12,180
Finland	9,217	10,378	[r] 9,230	8,872	• 8,678
France	126,278	131,133	136,638	142,984	• 148,258
Germany:					
East	33,814	35,690	37,818	42,087	44,248
West	197,195	200,132	203,685	184,631	• 198,966
Greece	15,667	18,833	21,038	20,217	23,440
Hungary	13,233	13,972	15,250	15,564	16,414
Iceland	633	668	674	680	586
Ireland	5,705	6,168	6,526	7,606	7,928
Italy	133,918	121,341	[r] 131,440	158,954	173,081
Luxembourg	1,202	1,302	1,243	1,072	• 1,055
Netherlands	16,845	17,432	18,546	19,625	20,135
Norway	9,035	9,399	10,712	12,611	13,472
Poland	51,368	56,129	58,873	65,269	67,976
Portugal	9,510	9,850	10,085	10,671	10,905
Rumania	27,862	31,697	34,511	37,141	41,172
Spain (includes Canary Islands)	49,838	[r] 56,830	[r] 70,771	78,172	• 88,486
Sweden	21,260	22,134	[r] 22,010	22,485	22,924
Switzerland	25,341	23,682	25,365	24,471	25,321
U.S.S.R	380,728	424,433	469,017	496,928	512,750
United Kingdom	99,477	[r] 99,450	[r] 98,360	108,189	104,425
Yugoslavia	17,819	18,188	18,950	19,414	22,063
Africa:					
Algeria	4,603	4,333	3,864	4,249	4,278
Angola	1,255	1,437	1,548	1,635	1,828
Cape Verde Islands	70	• 70	---------	NA	NA
Congo (Kinshasa)	1,319	1,454	1,548	• 1,524	NA
Ethiopia	258	563	586	879	1,000
Ghana	---------	---------	---------	---------	1,348
Ivory Coast	---------	---------	627	1,500	1,934
Kenya	2,474	2,838	2,838	2,807	3,194
Malagasy Republic	[r] 252	229	[r] 299	352	398
Malawi	182	182	258	255	325
Morocco	5,435	4,632	5,025	5,028	5,837
Mozambique	1,067	1,290	1,319	1,453	• 1,682
Niger	NA	NA	88	129	135
Nigeria	3,887	5,764	5,875	4,594	3,364
Rhodesia, Southern •	1,466	1,466	1,466	NA	NA
Senegal	1,202	1,061	1,137	1,026	1,185
South Africa, Republic of	20,258	22,761	23,359	[r] 23,200	• 23,800
Sudan	534	469	586	779	852

Table 22.—World production of hydraulic cement, by countries—Continued

(Thousand 376-pound barrels)

Country	1964	1965	1966	1967	1968 [p]
Tanzania	---------	---------	281	878	914
Tunisia	2,668	2,662	2,808	2,766	• 2,754
Uganda	428	768	709	815	900
United Arab Republic	14,781	14,201	[r] 14,810	16,144	NA
Zambia	885	1,296	1,290	1,758	1,641
Asia:					
Afghanistan [2]	788	997	1,026	762	1,037
Burma	768	792	827	774	996
Cambodia	• 59	• 298	346	• 352	• 352
Ceylon	440	504	487	1,108	1,801
China (mainland) •	61,565	64,496	64,496	46,880	52,740
Cyprus	410	575	580	1,096	1,412
Hong Kong	1,261	1,418	1,448	1,260	1,518
India	56,815	62,022	[r] 64,794	68,562	69,968
Indonesia	2,574	2,140	1,982	2,051	2,408
Iran [2]	4,368	4,601	8,171	8,175	• 8,204
Iraq	6,403	7,534	7,869	• 8,204	• 8,204
Israel	6,438	7,388	6,848	4,717	• 7,032
Japan	193,377	191,665	224,359	251,939	281,838
Jordan	1,806	1,788	2,199	1,881	2,238
Korea:					
North •	15,303	14,072	14,658	15,236	15,822
South	7,282	9,463	11,023	14,298	20,982
Lebanon	5,166	5,687	6,426	5,954	5,809
Malaysia	2,732	4,333	• 4,981	• 4,893	5,274
Pakistan	9,065	10,009	[r] 10,818	11,943	14,281
Philippines	7,042	8,965	9,458	12,376	15,494
Ryukyu Islands	---------	598	751	879	• 870
Saudi Arabia	1,519	1,483	1,466	1,898	• 2,344
Singapore	• 1,172	1,190	2,275	2,760	3,828
Syrian Arab Republic	3,723	3,952	3,618	• 3,516	• 3,575
Taiwan	13,808	14,330	18,247	20,484	23,899
Thailand	6,215	7,323	8,695	10,179	13,859
Turkey	17,238	19,513	22,662	24,899	27,735
Vietnam:					
North	3,805	4,397	• 4,397	• 4,397	• 2,930
South	440	1,143	792	1,061	850
Oceania:					
Australia	21,260	22,292	21,542	22,368	23,030
Fiji Islands	182	235	240	275	299
New Zealand	4,620	4,937	5,148	4,770	• 4,477
Total • [3]	2,437,486	2,543,258	2,722,068	[r] 2,831,956	2,985,279

• Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Sales.

[2] Year ended March 20 of year following that stated.

[3] Total is of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/53

Chromium

By John L. Morning [1]

Metallurgical-grade chromite prices for 1969 deliveries rose as the United Nation's economic sanctions against Southern Rhodesia continued for the second year. The removal of Southern Rhodesian chromite from the marketplace reduced metallurgical-grade chromite imports, and stocks dropped to the lowest level since 1952. However, sales of surplus chromite from the Government stockpile increased the available supply by 134,574 short tons in 1968. Chromite under contract for delivery in 1969 and subsequent years totaled over 400,000 tons.

Legislation and Government Programs.—A barter contract negotiated in 1964 was completed during the year with a final shipment of 1,000 tons of high-carbon ferrochromium to the Government stockpile.

Government sales of chromite were concentrated in a long-range program for the disposal of metallurgical-grade chromite in excess of stockpile needs. Sales totaled 614,444 tons, and deliveries totaled 134,574 tons. Deliveries in 1967 were revised to 71,179 tons. Chromite sold under contract for shipment in 1969 and subsequent years totaled 437,406 tons at yearend. In October, the General Services Administration (GSA) offered for sale 184,000 tons of metallurgical-grade chromite on a competitive bid basis. No acceptable bids were received, and the material was reoffered for sale under negotiated offers. Most of the chromite was sold early in 1969. GSA, in reoffering 22,400 tons of chemical-grade chromite, found no takers for the third successive year.

Table 1.—Salient chromite statistics

(Thousand short tons)

	1964	1965	1966	1967	1968
United States:					
Exports	6	7	19	8	18
Reexports	32	95	173	157	126
Imports for consumption	1,428	1,518	1,864	1,240	1,084
Consumption	1,451	1,584	1,461	1,355	1,316
Stocks Dec. 31: Consumer	1,287	1,111	1,306	1,197	895
World: Production	4,583	5,301	4,843	4,720	5,206

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—U.S. defense materials inventories and objectives

(Thousand short tons)

Type of material	Objective	Inventory by program, Dec. 31, 1968: National stockpile	Defense Production Administration	Commodity Credit Corporation and supplemental stockpile	Total
Chromite, chemical: Stockpile grade	591	559	-------	484	1,043
Chromite, refractory:					
Stockpile grade	1,425	1,047	-------	380	1,427
Nonstockpile grade	-----	(1)	-------	-------	(1)
Chromite, metallurgical:					
Stockpile grade	2,509	2,087	(1)	373	2,460
Nonstockpile grade	-----	767	901	-------	1,668
Ferrochromium, high-carbon:					
Stockpile grade	65	125	-------	276	401
Nonstockpile grade	-----	1	-------	-------	1
Ferrochromium, low-carbon:					
Stockpile grade	80	107	-------	191	298
Nonstockpile grade	-----	20	-------	-------	20
Ferrochromium-silicon:					
Stockpile grade	58	25	-------	31	56
Nonstockpile grade	-----	(1)	-------	2	3
Chromium metal, electrolytic: Stockpile grade	3	1	-------	3	4
Chromium metal, aluminothermic: Stockpile grade	3	-------	-------	4	4

---

[1] Less than ½ unit.

DOMESTIC PRODUCTION

Domestic mine production of chromite ceased in 1961 when the last Government Defense Production Act contract was concluded. However, the United States in 1968 continued to be the free world's leading chromite consumer, in producing chromium alloys, refractories, and chemicals. The principal producers of these products follows:

Company	*Plant*
Metallurgical industry:	
Airco Alloys and Carbide Division, Air Reduction Co. Inc	Calvert City, Ky. Niagara Falls, N.Y. Charleston, S.C.
Chromium Mining and Smelting Corp	Woodstock, Tenn.
Foote Mineral Co	Vancoram, Ohio. Graham, W. Va.
Interlake Steel Corp	Beverly, Ohio.
Ohio Ferro-Alloys Corp	Brilliant, Ohio. Takoma, Wash.
Shieldalloy Corp	Newfield, N.J.
Union Carbide Corp	Niagara Falls, N.Y. Marietta, Ohio. Alloy, W. Va.
Refractory industry:	
A. P. Green Refractory Co	Mexico, Mo.
The Babcock & Wilcox Co	Augusta, Ga.
Basic, Inc	Maple Grove, Ohio.
Corhart Refractories Co	Buckhannon, W. Va. Louisville, Ky.
E. J. Lavino & Co. (Division of IMC)	Newark, Calif. Plymouth Meeting, Pa.
General Refractories Co	Baltimore, Md. Gary, Ind. Lehi, Utah.
H. K. Porter Co., Inc	Pascagoula, Miss.
Harbison-Walker Refractories Co. (Division of Dresser Industries, Inc.)	Warm Springs, Calif. Hammond, Ind.
Kaiser Aluminum Chemical Corp	Moss Landing, Calif. Columbiana, Ohio.
North American Refractories Co	Womelsdorf, Pa.
Ohio Fire Brick Co	Jackson, Ohio.
Chemical industry:	
Diamond Shamrock Corp	Kearny, N.Y. Painsville, Ohio.
Imperial Color & Chemical Department, Hercules Inc	Glenns Falls, N.Y.
PPG Industries, Inc	Corpus Christi, Tex.
Allied Chemical Corp	Baltimore, Md.

CONSUMPTION AND USES

Of the total chromite consumed, the metallurgical industry used 61 percent, the refractory industry 24 percent, and the chemical industry 15 percent. Bureau of Mines statistics do not include the quantity of chromite consumed as chromite sand for use as a molding material in the foundry industry. Worldwide usage for this application has been estimated at 70,000 to 80,000 tons.[2]

The metallurgical industry consumed 796,000 tons of chromite containing 271,000 tons of chronium in producing 369,000 tons of chromium ferroalloys and chromium metal. An additional 8,000 tons of chromite, containing 4,000 tons of chromium, was added directly to steel. Of the 796,000 tons consumed in making chromium ferroalloys and metal, 772,000 tons averaging 50.1 percent chromic oxide (Cr_2O_3) was classified by consumers as metallurgical-grade ore; 10,000 tons averaging 44.0 percent Cr_2O_3 was classified as chemical-grade ore; and 14,000 tons averaging 37.5 percent Cr_2O_3 was classified as refractory-grade ore. Eighty-five percent of the metallurgical-grade ore had a chromium-to-iron ratio of 3:1 and over; 12 percent had a ratio between 2:1 and 3:1 and 3 percent had a ratio of less than 2:1.

Producers of chromite-bearing refractories consumed 310,000 tons of ore containing 73,000 tons of chromium. An additional 1,000 tons was used directly in furnace repairs. The chemical industry consumed 202,000 tons of chromite containing 62,000 tons of chromium in producing 147,000 tons of chemicals (sodium bichromate equivalent).

A new chromium alloy was introduced by major ferroalloy producers. The alloy contains 40 to 42 percent chromium, 39 to 42 percent silicon, and 0.05 percent carbon. With its higher chromium-to-silicon ratio and low cost, it was expected to have an economic advantage over other ferrochromium-silicons.

Union Carbide marketed a new ferrochromium alloy containing 62 percent chromium, 5 percent manganese, 1.5 percent silicon, and 5.25 percent carbon. The new ferrochromium was claimed to have a 40 percent faster solution rate, thereby allowing steel producers to make large ladle additions without increasing tapping temperature. Additional benefits claimed were reduced refractory costs, increased recoveries, better overall furnace operation, and less segregation in ingots.

---

[2] Industrial Minerals. Chromite Sand: A Fourth Dimension for Ore Suppliers. No. 13, October 1968, pp. 9–13.

Table 3.—Consumption of chromite and tenor of ore used by primary consumer groups in the United States

(Thousand short tons)

Year	Metallurgical industry		Refractory industry		Chemical industry		Total	
	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)	Gross weight	Average Cr_2O_3 (percent)
1964	832	49.0	430	33.8	189	45.1	1,451	44.0
1965	907	49.8	460	34.7	217	45.0	1,584	44.8
1966	828	49.6	439	34.6	194	44.9	1,461	44.5
1967	866	49.7	310	34.0	179	45.2	1,355	45.5
1968	804	49.7	311	34.1	202	45.1	1,316	45.4

Table 4.—Production, shipments, and stocks of chromium ferroalloys and chromium metal in 1968

(Short tons)

Alloy	Production		Shipments	Producer stocks Dec. 31
	Gross weight	Chromium content		
Low-carbon ferrochromium	90,474	63,694	92,810	13,109
High-carbon ferrochromium	183,815	126,741	176,124	29,981
Ferrochromium silicon	76,862	31,078	77,916	10,375
Other [1]	17,511	13,381	17,962	2,485
Total	368,662	234,894	364,812	55,950

[1] Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Table 5.—Consumption, by end uses, and stocks of chronium ferroalloys and metal in the United States, in 1968

(Short tons)

	Ferrochromium				Ferrochromium silicon		Other chromium alloys[1]	
	Low Carbon		High Carbon					
	Gross weight	Contained weight	Gross weight	Contained weight	Gross weight	Contained weight	Gross weight	Contained weight
Steel (ingots and castings):								
High speed and tool	1,129	788	2,653	1,748	217	101	16	16
Stainless	119,655	82,578	71,270	47,792	60,643	24,048	301	200
Alloy (excluding stainless)	13,568	9,263	42,711	27,986	9,702	4,131	323	180
Carbon	1,999	836	5,856	3,594	2,606	1,138	1,127	588
Other steel	1,187	818	286	185	------	------	321	164
Cast irons	1,878	1,107	7,475	4,986	23	11	322	238
Cutting and wear resistant materials	161	118	1,110	756	------	------	76	68
Welding and hard facing rods and materials	450	308	813	554	------	------	179	176
Nonferrous alloys	8,822	6,305	891	586	588	273	2,177	2,079
Miscellaneous and unspecified[2]	4,166	2,819	2,765	1,823	1,565	733	504	487
Total	152,215	104,940	135,830	90,010	75,344	30,435	5,246	4,196
Consumer stocks Dec. 31, 1968	14,062	NA	10,290	NA	3,958	NA	866	NA

NA Not available.
[1] Includes aluminothermic and electrolytic metal and other chromium alloys.
[2] Includes electrical materials, catalysts and other chemical and ceramic uses.

Interest continued in the development of chromite sand as a molding material in the foundry industry.[3]

As part of a program to develop methods of utilizing domestic chromite resources, Bureau of Mines' researchers conducted low-temperature chlorination studies on various types of ferrochromium.[4] The objective was to devise a method for separation of chromium and iron in low-quality, high-carbon ferrochromium. Iron was successfully volatilized as the chloride, while chromium remained in the residue as a nonvolatile chloride. Recovery of the chromium in a leach solution of the residue varied from 82 to 93 percent.

STOCKS

Chromite stocks dropped to the lowest quantity since 1952. Although chemical and refractory chromite inventories were more than adequate at yearend, metallurgical chromite stocks represented about 5 months' supply. Producers' stocks of chromium alloys increased 7 percent, whereas consumer stocks decreased 21 percent. Stocks of chromium chemicals (sodium bichromate equivalent) at producers' plants decreased from 9,115 tons in 1967 to 8,150 tons in 1968.

Table 6.—Consumers' stock of chromite, Dec. 31

(Thousand short tons)

Industry	1964	1965	1966	1967	1968
Metallurgical	509	443	463	459	381
Refractory	600	526	578	486	307
Chemical	178	142	265	252	207
Total	1,287	1,111	1,306	1,197	895

PRICES

Metallurgical-grade chromite prices moved substantially upward in October because 1969 Soviet chromite contracts called for an increase of about $9 per ton. The Turkish chromite price also moved upward, increasing $3 per ton; the South African Transvaal chromite price remained unchanged during the year.

Chromium alloy prices were unchanged until late in the year when high-carbon ferrochromium, charge chrome, and blocking chrome prices were increased 0.4 cent per pound of contained chromium. Early in 1969 the prices of low-carbon ferrochromium products were reduced 2 cents per pound of contained chromium.

---

[3] Middleton, J. M., and F. F. Bownes. Chromite Sand Its Application in the Steel Foundry. Ind. Miner., No. 13, October 1968, pp. 15–18. Work cited in footnote 2.

[4] de Beauchamp, R. L., and T. A. Sullivan. Low-Temperature Chlorination of Ferrochromium. BuMines Rept. of Inv. 7088, March 1968, 8pp.

Imported high-carbon ferrochromium was quoted about 3 cents lower per pound of contained chromium than domestic material; imported charge chromium was quoted about 1 cent lower per pound of contained chromium than domestic.

Table 7.—Price quotations for various grades of foreign chromite in 1968

Source	Cr_2O_3 (percent)	Chromium-iron ratio	Price per long ton, Jan. 1 [1]	Price per long ton, Dec. 31 [1]
South Africa, Republic of (Transvaal)	44	-----	$19.00–$21.50	$19.00–$21.50
Turkey	48	3 : 1	34.50– 35.50	37.50– 38.50
U.S.S.R	48	4 : 1	------------	40.00– 42.00
U.S.S.R	54–56	4 : 1	36.50– 40.00	45.20– 49.20

[1] Dry basis, subject to penalties if guarantees are not met, f.o.b. cars Atlantic ports, price nominal.
Source: Metals Week.

FOREIGN TRADE

Exports and reexports of chromite ore and concentrate decreased in quantity but increased in value compared with those of 1967. Exports were mainly to Canada; reexports were primarily to Canada and Mexico.

Ferrochromium exports to 16 countries totaled 27,127 tons valued at $5,734,690, and reexports totaled 345 tons valued at $124,251. Reexports decreased substantially compared with those of 1967. Belgium-Luxembourg, Canada, West Germany, and the United Kingdom received the major quantity of exports, and Canada received most of the reexports.

Chromium and chromium alloys, wrought or unwrought, and waste and scrap exports totaled 87 tons valued at $186,373. Canada, France, Japan, and the United Kingdom were the main recipients.

Exports of non-pigment-grade chromium chemicals totaled 667 tons valued at $674,557. While the quantity of these chemicals dropped 6 percent, the value increased sharply compared with 1967. Canada, Brazil, Japan, and Mexico were the leading recipients of the 30 countries receiving shipments. Exports of pigment-grade chromium chemicals totaled 140 tons valued at $153,314. Of the 19 countries receiving shipments, Canada, France, South Vietnam, and Venezuela accounted for 86 percent of the total.

Exports of sodium chromate and bichromate totaled 4,794 tons valued at $949,004. Canada (68 percent), Colombia (22 percent), and Mexico (3 percent) received 93 percent of the total shipments.

Imports of chromite ore decreased for the second year, owing to United Nations' economic sanctions against Southern Rhodesia. Metallurgical-grade ore (over 46 percent Cr_2O_3) comprised 45 percent of total imports, chemical-grade ore (40 to 46 percent Cr_2O_3) comprised 35 percent, and refractory-grade ore (under 40 percent Cr_2O_3) 20 percent.

Imports of chromium-containing pigments were as follows: Chrome green, 87 tons; chrome yellow, 3,311 tons; chromium oxide green, 686 tons; hydrated chromium oxide green, 208 tons; molybdenum orange, 106 tons; strontium chromate, 4 tons; and zinc yellow, 1,271 tons. Belgium-Luxembourg, Japan, Norway, and Poland supplied most of the imports.

Imports of unwrought chromium, other than alloys, and waste and scrap totaled 1,366 tons valued at $2,052,518. Japan and the United Kingdom were the principal suppliers. Chromium carbide received from Poland and West Germany totaled 89 tons valued at $344,916.

Imports of sodium bichromate and chromate increased 40 percent over those of 1967. Imports totaled 11,568 tons valued at $1,895,150 and were received principally from Italy, Japan, Republic of South Africa, and the U.S.S.R.

Table 8.—U.S. exports and reexports of chromite ore and concentrates

(Thousand short tons and thousand dollars)

Year	Exports		Reexports	
	Quantity	Value	Quantity	Value
1966	19	$740	173	$7,119
1967	8	328	157	5,422
1968	13	517	126	5,351

Table 9.—U.S. imports for consumption of ferrochromium, by countries

Year and country	Low-carbon ferrochromium (less than 3 percent carbon			High-carbon ferrochromium (3 percent or more carbon)		
	Short tons		Value (thousands)	Short tons		Value (thousands)
	Gross weight	Chromium content		Gross weight	Chromium content	
1967						
Belgium-Luxembourg	--------	--------	--------	551	382	$92
France	2,261	1,625	$605	28	19	5
Germany, West	4,902	3,662	1,413	1,499	1,043	271
Italy	--------	--------	--------	1,102	716	185
Japan	1,516	1,025	395	r 2,103	1,411	319
Norway	6,417	4,483	1,706	842	595	155
South Africa, Republic of	22,416	13,731	5,168	2,565	1,480	323
Sweden	7,347	5,410	2,098	--------	--------	--------
Turkey	3,792	2,662	942	--------	--------	--------
U.S.S.R	164	120	42	--------	--------	--------
Yugoslavia	154	109	39	--------	--------	--------
Total	48,969	32,827	12,408	r 8,690	5,646	1,350
1968						
Canada	3	1	1	--------	--------	--------
France	2,345	1,714	634	58	36	11
Germany, West	6,444	4,857	1,827	2,362	1,601	387
Italy	--------	--------	--------	1,102	716	175
Japan	477	314	127	1,778	1,196	297
Norway	6,085	4,489	1,611	66	46	15
South Africa, Republic of	25,250	16,430	5,903	1,745	954	198
Sweden	6,545	4,846	1,802	1,158	680	156
Turkey	3,314	2,351	796	--------	--------	--------
Yugoslavia	1,094	778	257	--------	--------	--------
Total	51,557	35,780	12,958	8,259	5,229	1,239

r Revised.

Table 10.—U.S. imports for consumption of chromite, by grades and countries, in 1968

(Thousand short tons and thousand dollars)

Country	Not more than 40 percent Cr$_2$O$_3$			More than 40 percent but less than 46 percent Cr$_2$O$_3$			46 percent or more Cr$_2$O$_3$			Total		
	Gross weight	Cr$_2$O$_3$ content	Value	Gross weight	Cr$_2$O$_3$ content	Value	Gross weight	Cr$_2$O$_3$ content	Value	Gross weight	Cr$_2$O$_3$ content	Value
Albania	----	----	-----	6	2	$120	----	----	-----	6	2	$120
Philippines	167	55	$3,088	----	----	----	----	----	-----	167	55	3,088
Rhodesia, Southern	----	----	-----	1	(1)	11	----	----	-----	1	(1)	11
South Africa, Republic of	25	9	334	307	136	3,328	92	46	$1,040	424	191	4,702
Turkey	30	12	405	62	27	1,135	59	29	1,430	151	68	2,970
U.S.S.R	----	----	-----	----	----	----	335	183	7,297	335	183	7,297
Total	222	76	3,827	376	165	4,594	486	258	9,767	1,084	499	18,188

[1] Less than ½ unit.

Table 11.—U.S. import duties

Tariff classification	Articles	Rate of duty, Jan. 1, 1969 [1]
	CHROMIUM ORES AND METAL PRODUCTS	
601.15	Chromium ore	Free.
607.30	Ferrochromium, less than 3 percent carbon	6.5 percent ad valorem.
607.31	Ferrochromium, over 3 percent carbon	0.625 cent per pound on chromium content.
632.18	Unwrought chromium other than alloys; waste and scrap [2]	8 percent ad valorem.
	CHROMIUM CHEMICALS AND RELATED PRODUCTS	
420.08	Potassium chromate and dichromate	1.8 cents per pound.
420.98	Sodium chromate and dichromate	1.4 cents per pound.
422.92	Chromium carbide	10 percent ad valorem.
	CHROMIUM PIGMENTS	
473.10	Chrome green	8 percent ad valorem.
473.12	Chrome yellow	Do.
473.14	Chromium oxide green	Do.
473.16	Hydrated chromium oxide green	Do.
473.18	Molybdenum orange	Do.
473.19	Strontium chromate	Do.
473.20	Zinc yellow	Do.

[1] Not applicable to Communist countries.
[2] Duty temporarily suspended on waste and scrap.

WORLD REVIEW

Canada.—Chromium Mining and Smelting Corp. planned to expand its processing facilities at Beauhanois, Quebec, in order to secure greater efficiency. Plans do not call for increasing the furnace capacity of the plant.

Finland.—The Outokumpu Oy. ferrochromium plant at Tornio started operations in 1968 and produced 836 tons of ferrochromium. In conjunction with the ferroalloy plant, a concentrating plant at Kemi initiated operations in 1967, treating 33,500 tons of crude ore in producing 7,037 tons of chromite concentrate. In 1968, the plant processed 118,000 tons of crude ore in producing 39,900 tons of concentrate.

Greenland.—Large, low-grade chromite deposits near the Fiskenaesset Peninsula were discovered in 1964, and geological studies were made in 1965 and 1966.[5] No attempt was made to quantify the total resource, but the survey indicated a very large, low-grade resource base. Analytical studies indicated that the Cr_2O_3 content of the chromite averaged 32.7 percent and total iron oxide (FeO) averaged 31.8 percent. The chromite also contains vanadium varying from 0.2 to 0.5 percent vanadium pentoxide (V_2O_5).

India.—Chromite was mined by both open-pit and underground methods. Hand mining predominated in both types. Open pits rarely exceed 30 to 35 meters in depth and are limited in length and width to small openings. Underground operations merely follow the ore in random patterns, thus limiting the extent and depth of development. Partial mechanization employed at the Tata Iron and Steel Company's Kittaburu (Orissa) operation includes a crushing plant, hydraulic classifier, and Wilfley tables for concentration; most of the mined ore, however, is crushed, sorted, jigged, and panned by hand to obtain the required product sizes and qualities.

Japan.—Japan's fast-rising ferroalloy industry planned to import about 780,000 tons of chromite during the year. Plans called for production of about 212,000 tons of ferrochromium in 1968 and 284,000 tons in 1971.

Nippon Ferro Alloys Co. dropped plans for producing extra-low-carbon ferrochromium with Union Carbide Corp.'s patented Simplex process in favor of Nippon Kokan K.K.'s vacuum process for making low-carbon ferrochromium. A new plant was expected to start production in 1969.

---

[5] Ghisler, Martin, and Brian F. Windley. The Chromite deposits of Fiskenaesset Region, West Greenland. Geol. Survey of Greenland, Copenhagen, Denmark, Rept. No. 12, 1967, 39 pp.

Table 12.—World production of chromite, by countries[1]

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
South America:					
Brazil [2]	10,406	18,695	16,495	7,567	15,247
Colombia	441	287	-----------	-----------	-----------
Europe:					
Albania	338,213	342,000	345,000	360,000	[e] 360,000
Finland	-----------	-----------	NA	7,037	39,899
Greece	[r] 56,100	[r] 55,800	[r] 61,500	13,228	[e] 14,300
U.S.S.R.[e] [3]	1,435,000	1,565,000	1,653,000	1,731,000	1,820,000
Yugoslavia	97,398	88,021	59,757	51,987	[e] 52,000
Africa:					
Malagasy Republic	12,974	2,628	-----------	-----------	-----------
Rhodesia, Southern	493,871	645,501	NA	NA	NA
South Africa, Republic of	936,468	1,038,498	1,169,488	1,266,615	1,270,667
Sudan [e]	18,700	33,000	19,000	20,000	33,000
Asia:					
Cyprus	3,300	5,501	11,532	24,037	27,672
India	38,547	65,791	85,601	120,740	226,698
Iran [e]	[r] 108,000	[r] 142,200	[r] 155,000	165,000	176,000
Japan	48,452	46,114	36,192	49,837	30,745
Pakistan	14,884	15,972	29,924	29,071	28,683
Philippines	515,969	611,288	617,426	462,694	446,282
Turkey	454,907	625,078	583,232	[r] 409,108	[e] 664,800
Oceania:					
Australia	80	25	-----------	154	-----------
New Caledonia	-----------	-----------	-----------	2,010	-----------
World total [4]	[r] 4,583,210	[r] 5,301,399	[r] 4,843,147	[r] 4,720,085	5,205,993

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Chromite was also produced in Bulgaria, Cuba, Rumania, and North Vietnam, but data not available.

[2] Bahia only.

[3] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[4] Total is of listed figures only.

Philippines.—Acoje Mining Co. planned to expand production of metallurgical-grade chromite as a result of an agreement with Japanese consumers. Production could increase to 160,000 tons annually during the next 3 years. Japan is committed to take 132,000 tons annually.

Rhodesia, Southern.—The United Nations' economic sanctions against Southern Rhodesia continued for the second year. Reportedly, chromite production was curtailed sharply, and output was being stockpiled. Despite the sanctions, an intensive hunt for minerals, including chromite, has been conducted. Seven exclusive prospecting orders for chromite and other minerals, covering 553 square miles, have been granted during the past 2 years.

Sudan.—Geological exploratory work was conducted on a chromite deposit in the Blue Nile Province by the Kamal Abdel Moneim International Co. If exploitable, a new 50-mile road would have to be constructed to the railhead at Roseries.

Turkey.—The latest Turkish Mineral Exploration Institute lists known reserves of chromite at 5.7 million tons and the estimated resource at 100 million tons.

TECHNOLOGY

Union Carbide Corp. developed a simplified manufacturing process for stainless steel. The addition of argon to the oxygen used in blowing stainless steel to remove carbon reduces the carbon monoxide partial pressure from 1 to 0.1 atmosphere in the melt chamber. This allows the carbon in the melt to be preferentially oxidized without oxidizing the chromium charged. Increased yields of the low-cost high-carbon ferrochromium charged helps to give an economic advantage to the process because less high-cost low-carbon ferrochromium is necessary to bring the melt to final specifications.

Various processes have been developed in recent years for production of tin-free steel for the packaging industry. The elimination of tin would substantially reduce the cost of container manufacture and meet increasing competition from aluminum containers. Bethlehem Steel Corp. described its process for a chromium-plated steel which is suitable for beer and carbonated-beverage packaging.[6]

The Bureau of Mines studied the feasibility of preparing chromium metal by thermal decomposition of bisbenzene chromium.[7] Chromium recovery was close to 100 percent, although the metal was contaminated by 0.3 percent carbon at low operating temperatures and by more than 10 percent at higher temperature. A unique property of the deposited metal was its corrosion resistance to mineral acids.

Bureau scientists developed a method for preparation of anhydrous chromous chloride ($CrCl_2$).[8]

---

[6] Ward, G. W., and S. E. Rauch, Jr., Bethlehem's Chromium Coated Tin Mill Product. Blast Furnace and Steel Plant, v. 56, No. 5, March 1968, pp. 229–234.

[7] Nash, B. D., T. T. Campbell, and F. E. Block. Chromium by Thermal Decomposition of Bisbenzene Chromium. BuMines Rept. of Inv. 7112, 1968, 19 pp.

[8] De Beauchamp, Robert L., and Thomas A. Sullivan. Preparation of Anhydrous Chromous Chloride. BuMines Rept. of Inv. 7194, 1968, 7 pp.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/14

Clays

By J. Robert Wells [1]

Domestic clay production in 1968, establishing a new annual record in terms of both tons and dollars, was nearly 5 percent greater in volume than in 1967 and slightly more than 5 percent higher in total value. Increases in both tonnage and value were reported for each of the individual types of clay, with the exception of fire clay which, although up about 1 percent in quantity, remained practically unchanged in aggregate dollar returns. Georgia, with an output of 5.1 million tons, continued in first place in total production, and with $89 million in total value, overtopped the next ranking State in that respect by a factor of almost 5. In 1968, exports of clay—approximately one-third shipped to Canada—outweighed imports about 20 to 1 both in value and in volume. Worthy of mention is the fact that the total tonnage of exports was over 32 percent greater than in 1967 and almost twice times the figure of just 5 years earlier.

Table 1.—Salient clay and clay products statistics in the United States

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
Domestic clays sold or used by producers	52,947	55,126	56,713	54,664	57,233
Value	$192,631	$204,932	$221,714	$223,987	$246,898
Exports	848	850	1,074	1,149	1,519
Value	$24,973	$25,595	$31,135	$32,432	$44,134
Imports for consumption	137	110	139	108	97
Value	$2,638	$2,137	$2,883	$2,235	$1,951
Clay refractories, shipments (value)	$205,267	$228,876	$243,516	[r] $225,116	$229,660
Clay construction products, shipments (value)	$569,200	$578,190	$554,667	$538,110	$590,776

[r] Revised.

DOMESTIC PRODUCTION, PRICES, AND FOREIGN TRADE, BY TYPE OF CLAY

KAOLIN

The quantity of kaolin sold or used by domestic producers in 1968 was 6 percent greater than in the previous yearend, with a substantial advance in the reported unit price, represented a 14-percent increase in total value.

Imports of kaolin, mostly from the United Kingdom but with small quantities from three other countries, maintained the downward trend of recent years, declining to a total of about 75,000 tons valued at $1.4 million, almost one-fifth less than the 92,000 tons and $1.8 million in 1967 and not much more than half the 1966 imports. Kaolin exports, on the other hand, have been growing notably for a number of years, and the 1968 totals, 390,000 tons and $13.0 million—up from 322,000 tons and $9.9 million in 1967—attested to the continuation of an expansion that, within the 1964–68 period, has been nearly threefold in both value and tonnage. Canada, accounting for about one-fifth of the exported material, was the leading recipient, followed by Japan, Italy, and West Germany. About 50 other countries received minor quantities that ranged from 2 tons to 19,000 tons.

---

[1] Physical scientist, Division of Mineral Studies.

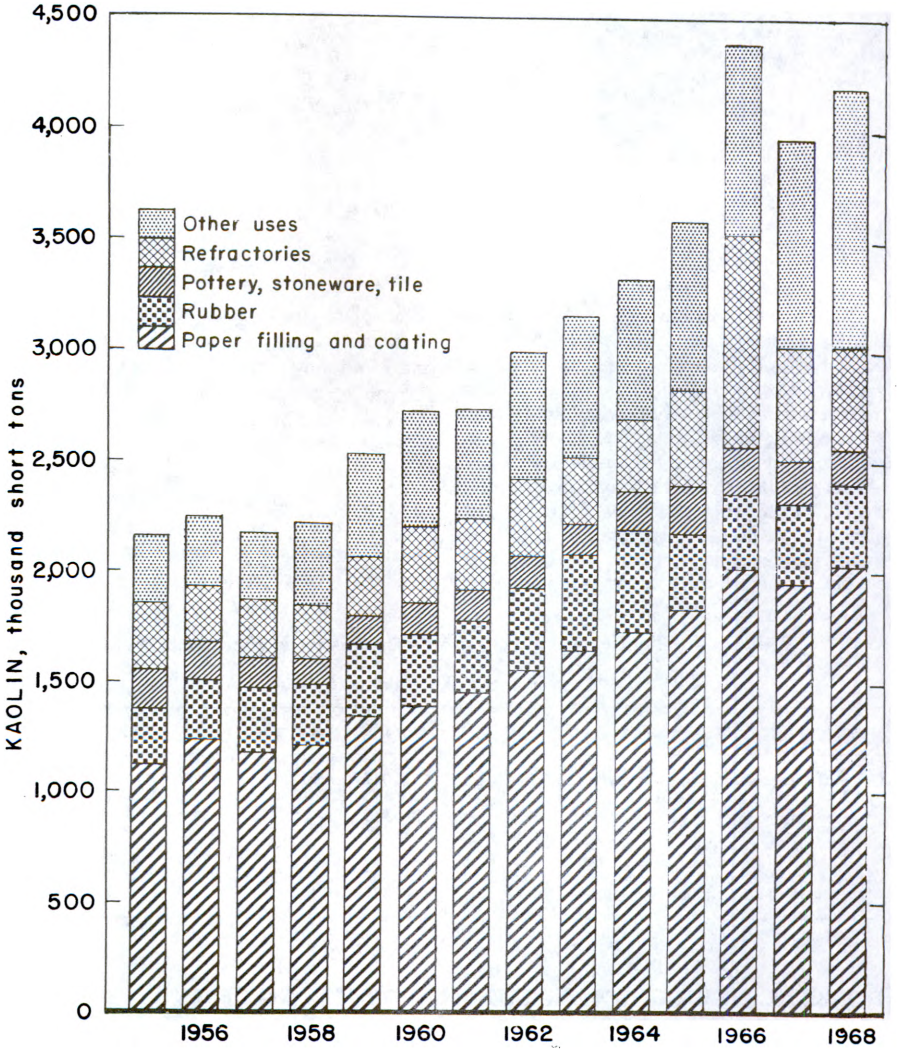

Figure 1.—Kaolin sold or used by domestic producers for specified uses.

Kaolin prices, as quoted in Oil, Paint and Drug Reporter, December 30, 1968, were as follows:

Water washed, calcined, bulk, carload lots, f.o.b. Georgia	$57.50 –$58.50
Water washed, partially calcined, same basis	44.50
Water washed, paper grade, uncalcined, same basis:	
No. 1 coating	36.00 – 36.50
No. 2 coating	28.00 – 28.50
No. 3 coating	27.00 – 27.50
Water washed, delaminated, 1-micron average, same basis	$59.00
Dry ground, air floated, soft, same basis	$12.50
National Formulary, powder, fiber drums, per pound	$0.10 – $0.12
National Formulary, colloidal, 50-pound bags, per pound	0.155– 0.175

BALL CLAY

Domestic production of ball clay in 1968 reversed the declining trend of the last few years and went on to establish record highs for both volume and value. Tennessee, the foremost producing State, with more than two-thirds of the total output, was followed in order by Kentucky, Mississippi, California, Texas, and Maryland.

Consumption of ball clay increased in roughly the same proportion in all the major use categories in 1968, so that the overall use pattern was essentially an amplified replica of that of 1967.

U.S. imports in 1968 included 14,025 tons of unbeneficiated ball clay and 3,359 tons of beneficiated ball clay, both predominantly from the United Kingdom and valued at $182,348 and $98,291, respectively—tonnages and values not notably different from the corresponding figures for 1966 and 1967.

Ball clay prices were quoted in Oil, Paint and Drug Reporter, December 30, 1968 as follows: Domestic, air-floated, bags, carload lots, Atlantic ports, $49 to $50.75 per ton; domestic, crushed, moisture-repellant, bulk, carload lots, Tennessee, $8 to $11.25 per ton; imported, air-floated, bags, carload lots, Atlantic ports, $49.50 to $50.75 per ton; imported, lump, bulk, Atlantic ports, $31.50 to $37.50 per ton.

FIRE CLAY

The total quantity of fire and stoneware clay sold or used by domestic producers in 1968 was 1 percent greater than in 1967, the first such increase since 1965, but the reported total value represented a fractional decline.

Fire clay exports decreased in 1968 for the third consecutive year in both tonnage and dollars, amounting to about 152,000 tons valued at $2.7 million, as compared with 176,000 tons and $2.8 million in 1967. The 1968 figures for tonnage and value were the lowest since those recorded in 1961 and 1959, respectively. Imports of fire clay were insignificant.

Some details of operating innovations in the open-pit mining of Missouri fire clays that enabled a major refractories producer to achieve substantially increased production and important cost savings were reported in a magazine article.[2]

Control of Quigley Co. Inc., a major manufacturer of fire clay and specialty refractories, was acquired by Chas. Pfizer & Co. Quigley will be operated as a Pfizer subsidiary.

A description was published of the expanded facilities of the Johns-Manville Corp. at Zelienople, Pa., where insulating firebrick are manufactured in a variety of temperature-range classes and sizes, notably in slabs that exceeded, by a factor of 7, the volume of the traditional 9-inch units. Johns-Manville also completed recently a similar installation in Italy.[3]

A. P. Green Refractories Co., a subsidiary of United States Gypsum Co., announced plans for the installation of a large processing complex near Oran, Mo., for multiple-step beneficiation of local fire clay raw materials. The new facility will be the 23d A. P. Green clays treatment plant in the United States and Canada.

The Harbison-Walker Refractories Co. plant at Canon City, Colo. was closed early in 1968. Changes in steel industry refractories requirements reduced the demand for the types of firebrick being manufactured at this plant.

Manufacturing of fire clay refractories and kiln furniture was started at the new plant of Applied Ceramics, Inc., near Doraville, Gwinnett County, Ga.

BENTONITE

Domestic production of bentonite has increased either in quantity or total value, or both, in all but five of the last 20 years. The 1968 output, approximately 18 percent more than in 1967, was in both respects and by a substantial margin, the highest ever recorded.

The quantities of bentonite consumed in its major end uses were, in general, sharply higher than in 1968, although consumption in iron ore pelletizing declined by about 1 percent, the first such decrease since data on this item were first reported separately.

More bentonite was exported from the United States in 1968 than in any previous year—477,000 tons valued at $11.0 million, as against 319,000 tons and $7.7 million in 1967—but imports were, by comparison, of minor significance, consisting of only

---

[2] Engineering and Mining Journal. New Fleet Slices Fire Clay Stripping Costs. V. 169, No. 1, January 1968, p. 94.

[3] Oberschmidt, Leo E. Johns-Manville Expands IFB Plant To Push Larger Unit Concept. Brick & Clay Record, v. 152, No. 3, March 1968, pp. 43–45.

146 tons worth $6,600 received from Italy. Of the material exported in 1968, Canada received 66 percent of the total, Australia and the Netherlands 8 percent each, and the United Kingdom 6 percent. The remaining 12 percent was distributed in varying amounts to more than 60 other countries.

Prices for bentonite quoted in Oil, Paint and Drug Reporter, December 30, 1968, were as follows: Domestic, 200-mesh, in bags, carload lots, f.o.b. mines, $14 per ton; imported Italian, white, high gel, in bags, 5-ton lots, ex-warehouse, $91 per ton. The unit value of domestic bentonite sold or used by producers averaged $9.83, a decrease of $0.20 per ton from the 1967 figure and the fifth consecutive annual reduction.

There was a continuing expansion of bentonite production capacity in Montana. Hallet Mineral Co. announced that it will double the output—at present 1,100 tons per day—from its bentonite mine near Vananda, Rosebud County, and Ashland Chemical Division of Ashland Oil & Refining Co. disclosed plans to construct a processing plant capable of handling large tonnages of bentonite from its recently acquired properties near Glasgow in Valley County.

FULLER'S EARTH

The quantity of fuller's earth sold or

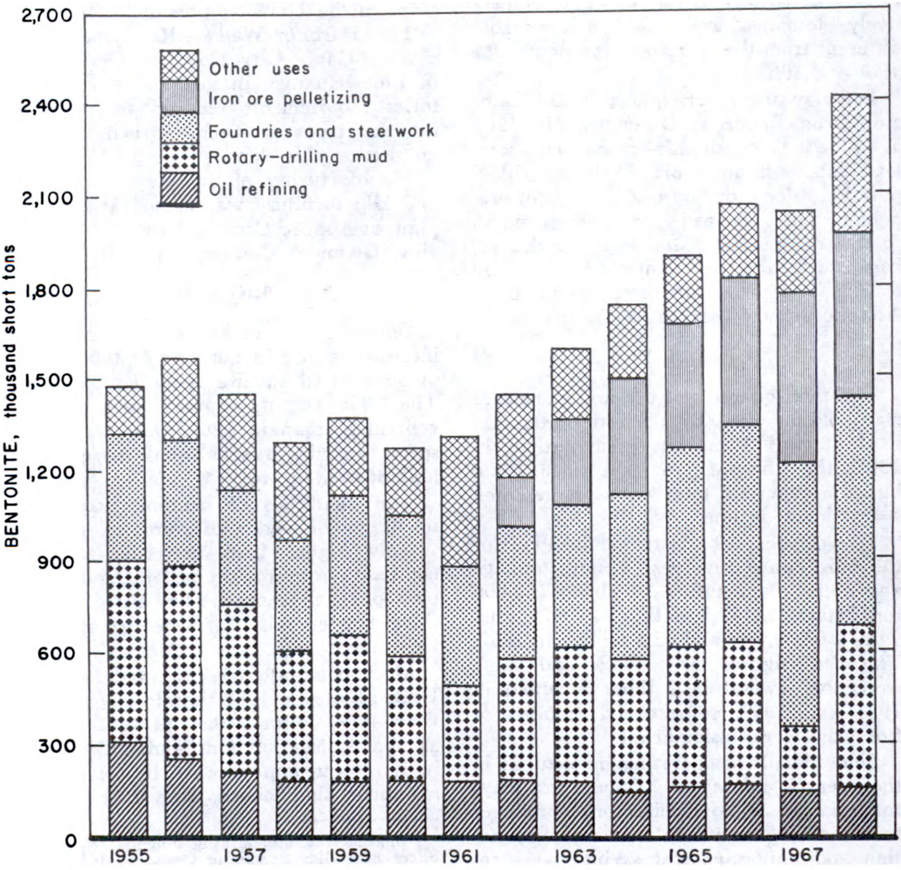

Figure 2.—Bentonite sold or used by domestic producers for specified uses.

used by producers in the United States increased in 1968 for the sixth consecutive year, bringing the annual total to the highest point in history, 15 percent above the 1967 figure and approximately twice that recorded 5 years ago. Florida, Georgia, and Mississippi led the nine States that reported production of fuller's earth in 1968.

Absorbent uses have provided by far the most important outlet for fuller's earth for many years. The quantity devoted to these

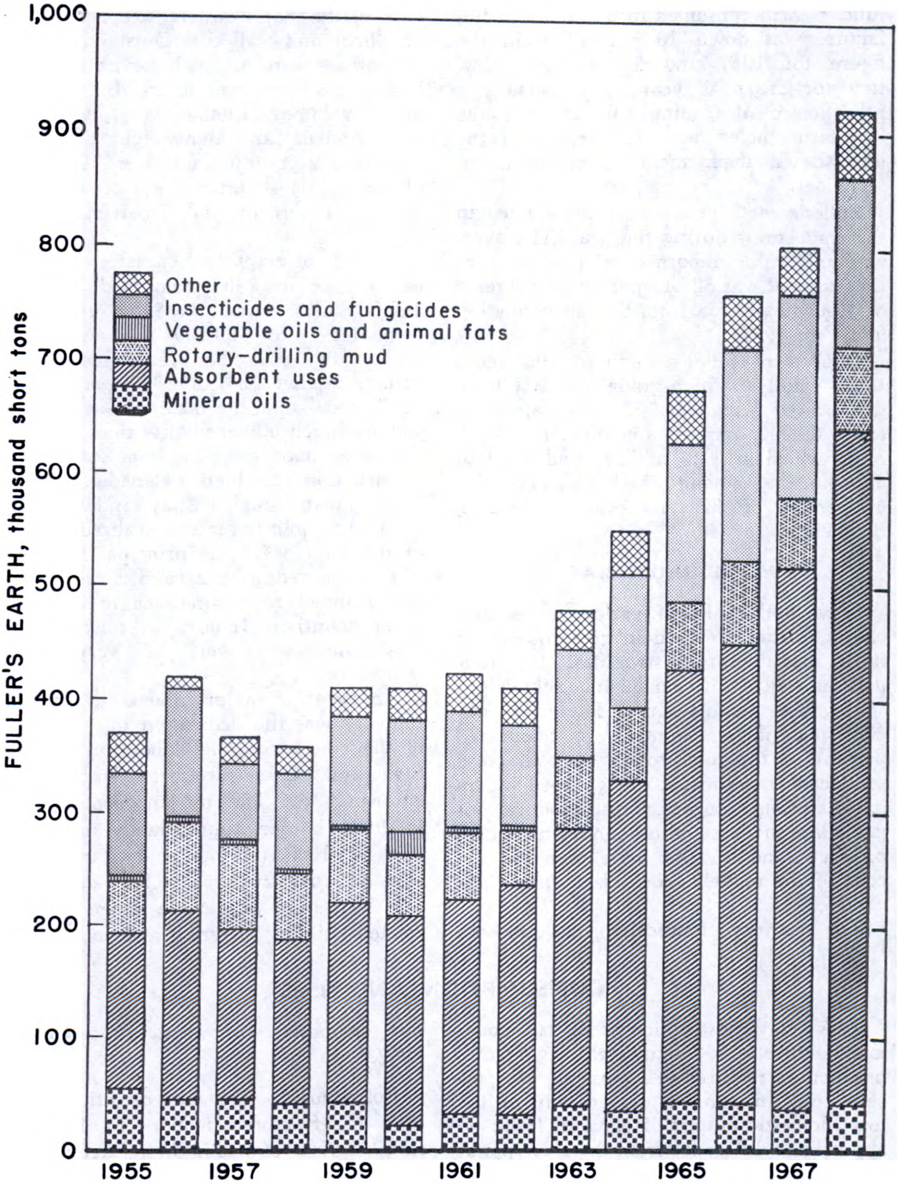

Figure 3.—Fuller's earth sold or used by domestic producers for specified uses.

purposes in 1968—two-thirds of the year's total—was 25 percent greater than in 1967. It was estimated that about half the quantity reported as used for absorbents was in the form of bagged material sold for animal litter, a market that has continued to expand at a noteworthy rate. The tonnage of fuller's earth consumed in pesticides manufacture was down 18 percent from the figure for 1967 and 22 percent below that for the peak year 1966, possibly a reflection of deepening concern over the long-term biological consequences of the unrestricted deployment of chemical insecticides.

Fuller's earth prices were not quoted in the trade press during the year. The average unit value reported by producers of the material was $25.15 per ton, a decrease of 40 cents per ton from the corresponding figure for 1967.

Imports of fuller's earth in 1968 consisted wholly of high-grade material from the United Kingdom—77 tons valued at about $9,000. Exports amounted to 42,000 tons, valued at $1.9 million, and went to 30 countries, among which Canada, with 43 percent of the total, was the leading recipient.

MISCELLANEOUS CLAY

Clays and shales of various types and characteristics are used in great quantities in the manufacture of structural clay products, as well as in cement and lightweight aggregates manufacture. These diverse clay materials, amounting to about 70 percent of the total tonnage of all clays produced domestically, are grouped in the miscellaneous category. Most producers of miscellaneous clay also manufacture clay products, and in 1968 more than 96 percent of the miscellaneous clay output was captive.

The quantity of miscellaneous clay sold or used by U.S. producers in 1968, almost 41 million tons, was an alltime record and represented an increase, compared with the respective figures for 1967, of 4 percent in volume and 9 percent in value.

There were significant increases in the quantities of miscellaneous clay going to each of the major outlets except stoneware and floor and wall tile. Outstanding rates of increase were recorded for utilization in both refractories and fillers. In the three largest-volume outlets—heavy clay products, cement, and lightweight aggregates (together accounting for over 98 percent of the total)—there were increases of 5 percent, 1 percent, and 6 percent, respectively.

Exports of clays not separately classified as to type in 1968 amounted to about 460,000 tons, valued at $15.5 million, as compared with 300,000 tons and $10.5 million in 1967. The respective per-ton values, around $34 in 1968 and $35 in 1967, show that the materials in question were of much higher quality than the usual run of common clays for large-scale use in construction products. Canada, Netherlands, Japan, Mexico, Italy, and Australia, accounting jointly for almost three-quarters of the total, were the principal recipients of the exported material, and the remainder was shipped to destinations in about 80 other countries. Imports of miscellaneous clays in 1968 were of very minor importance.

An event of major interest to the clay industry was the dedication in June 1968 of the new offices and laboratories of the Structural Clay Products Institute at McLean, Va. The ultramodern research facilities, housed appropriately in a complex of brick buildings of outstanding design and construction, include equipment for the testing of a wide range of clay-related building materials and components.

CONSUMPTION AND USES

Heavy clay construction products, cement manufacture, and lightweight aggregates production required 41 percent, 20 percent, and 16 percent, respectively of the total domestic output of clays in 1968; no appreciable difference from the corresponding proportions in 1967. The total tonnage of clays used in refractories was slightly less than 9 percent of the total 1968 output, compared with about 10 percent in 1967.

Refractories.—The total quantity of clay used in refractories declined by 4 percent in 1968. Use of kaolin in refractories fell by 50,000 tons in 1968 and that of fire clay by 294,000 tons, but increased consumption of bentonite and miscellaneous clay in this application partly compensated for these losses. Shipments of fire clay refractories were 6 percent less in quantity and 5 percent less in total value than in 1967.

The total value of nonclay refractories shipments was about 3 percent higher than in 1967, although some categories of these products registered moderate declines. Silica refractories, with a 16-percent decrease in quantity, continued to lose ground to other types more in current demand, although the total value rose fractionally.

Heavy Clay Products.—Shipments of heavy clay products showed substantial gains as to both quantity and value in the large-volume categories—unglazed building brick, vitrified sewerpipe, floor and wall tile—but unglazed structural tile and facing tile, glazed and unglazed, registered decreases. The sharpest drop, more than 15 percent with respect to both volume and value, was that reported for unglazed structural tile.

Lightweight Aggregates.—Production of lightweight aggregates from clay and shale rose 6 percent in 1968, compared with a 5-percent increase in the previous year. A total of 67 plants, owned by 58 firms, were active during 1968. Texas, where seven firms operated eight plants, was first in output with about 14 percent of the national total. Following in order, and jointly contributing about 40 percent of the total, were Illinois (four firms, four plants), New York (six firms and plants), North Carolina (four firms and plants), California (six firms, eight plants), and Mississippi (one firm and plant). Varying quantities produced in 25 other States made up the remaining 46 percent of the total. There were 19 States in 1968 in which no production of clay and shale lightweight aggregates was reported.

The figures referring to the manufacture of clay and shale aggregates exclude lightweight aggregates produced from slate. The quantity of slate used for this purpose in 1968 was 707,000 tons, compared with 649,000 tons in 1967.

WORLD REVIEW

Australia.—An exploration team fielded jointly by the Bureau of Mineral Resources and the Queensland Geological Survey found commercially interesting deposits of bentonite in southeastern Queensland, near Miles and close to the mail rail line linking the area with the coast at Brisbane. An earlier discovery, also in Queensland but in the Springsure area about 200 miles from railhead, was of little practical significance because of the prohibitive cost of transportation and gave no promise of providing an economical replacement for imported foreign bentonite.

Canada.—Canadian processors of iron ore, currently consuming about 175,000 tons yearly of Wyoming bentonite in pelletizing their material, gave increasingly serious consideration to other sources of supply. It was reported that at least two firms achieved substantial cost-per-ton savings by purchasing bentonite mined on the volcanic island of Melos in the Greek Cyclades.

Czechoslovakia.—Construction was started near Bozicany of a kaolin flotation plant, reportedly the largest in Europe. Production is expected eventually to reach at least 80,000 tons per year, and total investment in the project is estimated at around $28 million. Near Zelenice, also in Bohemia, installation was completed of a large new plant that, when in full operation, will process up to 100,000 tons of bentonite annually.

Korea, South.—The Dong Bo Clay Industrial Co., with reserves of more than half a million tons of bentonitic material, invited the financial participation of investors in a proposed expansion of operations at the firm's mine in North Kyongsang Province. The mine product will be processed in an existing plant near Seoul to provide activated clay for clarifying and decolorizing purposes.

New Zealand.—New Zealand China Clays Ltd. took initial steps toward establishing, near Kerikeri on North Island, a new operation that will be capable of turning out kaolin competitive in both price and quality with material presently being imported. As planned, the facility will have sufficient capacity to satisfy the New Zealand domestic market and also will be the pilot plant for a larger installation that can provide substantial quantities of kaolin for export. On South Island, Canterbury Bentonite Ltd. inaugurated a new bentonite mining and processing operation near Coalgate, in Canterbury. Open-pit mining of a deposit, estimated to contain 12 million tons, will furnish material for iron ore pelletizing and other uses—perhaps even relieving Australia of at least part of the present costly necessity of importing long-haul Wyoming bentonite from across the Pacific.

U.S.S.R.—It was reported that extensive deposits of bentonite have been developed recently at Piervomaiskoie and at Tal-Youryakhskoie, near Magadan, in eastern Siberia. The Soviet Union's reserves of this clay material are described as huge, and although no quantitative data are ever released, it is inferred that the bentonite industry there ranks second only to that of the United States.

United Kingdom.—In Leeds, Yorkshire, the Kaiser Refractories Division of Kaiser Aluminum Co. Ltd. leased and began operating the production facilities of the Leeds Fireclay Co. Ltd. for the manufacture of specialty refractory products. Berk Ltd., began an expansion and modernization program designed to achieve a threefold increase in the production capacity of the processing plant formerly operated by Greensplat China Clay Ltd. near St. Austell in Cornwall. The envisioned improvements will provide for an output of 45,000 tons annually from the historic Greensplat Pit, source of high-quality china clay for well over a century.

TECHNOLOGY

A novel and advantageous process has been devised for sorting a given lot of clay into any required number of particle-size fractions. In this newly introduced method, referred to as probability sizing, a stream of the material falls on an array of comparatively coarse-meshed screens set at increasingly steep angles so that, in effect, the individual clay particles are presented with a virtually unlimited gradation of opening sizes. Advantages mentioned for this innovation include greater power economy, more trouble-free and relatively noiseless operation, together with greatly reduced weight, dimensions, and cost of the necessary machinery.[4]

Horizontal instead of vertical extrusion is the principle of a newly developed process for fabricating clay pipe in exceptionally large diameters. With the equipment thus far available the method produces sizes up to 48 inches in diameter, and it is stated that eventual construction of larger cradles and handling mechanisms will make even 72-inch pipe a possibility. The present machinery limits pipe lengths to 7 feet, but much longer sections could be supplied if demand warranted. The horizontal method, which is based on auger rather than piston extrusion, reportedly has the advantage of attaining a higher vacuum and a consequent better de-airing of the material. Additionally, the auger press, instead of giving rise to planes of lamination in the clay, tends to produce superior pipe reinforced by screw-wise texture lines.[5]

An article in a British journal briefly traced the evolution of technologies by which clay bricks, prehistoric to modern, have been shaped, fired, tested, and built into walls. An extensive list of references accompanied the article.[6]

A building process developed in Germany used burned-clay blocks or hollow tile that were shaped by diamond tools so as to interlock and thus form a solid wall without need for mortar expensively applied by hand. In the actual laying up of a wall, this innovation as compared with conventional masonry construction procedures, gave promise of a 70-percent saving in required labor costs.[7]

A process was described by which Georgia clays are converted into highly selective molecular-sieve zeolites. The finished products, serving as efficient catalysts capable of increasing by 50 percent the yield of gasoline from given grades of crude oil, command prices equal to 10 to 12 times the value of the kaolin-type starting material.[8]

---

[4] Stevenson, C. L., and H. W. Emrich. Probability Sizing of Clay Materials. Am. Ceram. Soc. Bull., v. 47, No. 9, September 1968, pp. 810–812.

[5] Oberschmidt, L. E. Dickey First to Extrude 36–38 Inch Pipe Horizontally. Brick & Clay Record, v. 153, No. 4, October 1968, pp. 42–45.

[6] Whiting, G. H. Recent Advances in Clay Brickmaking, Brick Testing and Brick Building. Chem. & Ind. (London), No. 3, Jan. 20, 1968, pp. 76–84.

[7] Steinmetz, Klaus. Diamond Tools Open Up New Possibilities for the Building Industry. Ind. Diamond Rev., v. 28, No. 327, February 1968, pp. 56–60.

[8] Chemical Week. Upgrading Clay by $600/Ton. V. 103, No. 23, Dec. 7, 1968, p. 28.

The most significant innovation incorporated in the Minerals & Chemical Corporation bentonite processing plant recently completed at Colony, Wyo., is a fluid-bed installation that provides precise control over the critically important temperature at which the product is dried. This new $1.5-million facility, which replaces an older mill just across the line in South Dakota, is highly automated and is designed to double the firm's bentonite output capacity.[9]

New uses for expanded clay and shale products were discussed at the August meeting of the Lightweight Aggregate Producers Association in Syracuse, N.Y. Special attention was given to the increasing utilization in concrete for road surfaces. A visit was made to two experimental projects which the New York State Department of Transportation has in progress to assess the advantages of the lightweight material for highway topping, an application in which it is said to afford a substantial safeguard against skidding hazards.[10]

Research conducted by engineers of the Texas Transportation Institute led to the conclusion that the superior skid resistance conferred by road surfaces, whether asphaltic or of concrete, which incorporate a proportion of lightweight aggregates is attributable to the fact that wear of the porous nodules continues to expose fresh sharp-edged voids, whereas under the same conditions, the solid particles of conventional aggregates tend to acquire a high polish that quickly nullifies their original frictional characteristics. A further advantage of the lightweight road surface that is worthy of consideration is the reduced frequency and severity of glass damage by loose stones hurled from speeding tires.[11]

A journal article described a process in which clays, shales, or certain other mineral materials that are not naturally bloatable can be used to produce lightweight aggregates with bulk densities of 35 to 47 pounds per cubic foot. The procedure involved dispersing the starting material as a clay-water slip, which was then converted to a foam and formed into stable globules by allowing drops of the foam to roll down an incline in contact with additional dry clay. The drying and firing of the resulting pellets followed conventional lines.[12]

Refractory components of extraordinary size and quality are being produced in a specially designed 125-ton vessel recently placed in service in West Virginia. The huge pressure chamber, one of the largest ever built for this purpose, makes it possible to realize the advantages of isostatic pressing for the shaping of high-alumina clays into blocks up to 2 by 2 feet in transverse dimensions and nine feet long. The isostatic process, while providing a substantial saving in fabrication time, permits the use of materials not amenable to fusion or slipcasting methods without sacrificing the high density or homogeneity of the product. The outsize refractory units, intended primarily for glassmaking use, are expected to provide superior furnace linings with a substantially reduced number of joints exposed to erosion.[13]

A new lightweight ceramic filler consisting of approximately spherical hollow particles has been developed for use in making brick, tile, or cement. Medium-duty firebrick incorporating this material are said to be superior in mechanical strength and as much as 40 percent lighter than equal-sized conventional units.[14]

A recent invention has been applied advantageously to the grinding of plastic clays. The new machine effects the comminution by advancing the clay through double, counter-rotating sets of flails of steel chain and has been used successfully for the milling of material containing up to 18 percent moisture.[15]

Bureau of Mines clays-related research in various stages of progress in 1968 included evaluation studies of local clay supplies for iron ore pelletizing, assessment of potential raw materials for production of expanded aggregates, search for improved materials and methods for the fabrication of longer-lived zinc retort condenser cones, and continuing exploration of processes and problems involved in the practical extraction from clays of alumina acceptable as aluminum smelter potline feed.

---

[9] Engineering and Mining Journal. New Plant in Wyoming Doubles IMC's Bentonite Production Capacity. V. 169, No. 1, January 1968, pp. 106, 108.

[10] Pit and Quarry. Growing Demand, New Uses Discussed by Lightweight Aggregate Producers. V. 61, No. 5, November 1968, p. 109.

[11] Engineering News-Record. Lightweight Aggregates are Superior. V. 180, No. 11, Mar. 14, 1968, p. 21.

[12] Modde, Michael F., and W. G. Lawrence. Foamed Clay-Water Systems for Lightweight Aggregate Production. Am. Ceram. Soc. Bull., v. 47, No. 3, March 1968, pp. 264–266.

[13] Oberschmidt, Leo. Corhart Takes a Giant Step in Isostatic Forming of Refractories. Brick & Clay Record, v. 153, No. 4, October 1968, pp. 50–53.

[14] Brick & Clay Record. Product News—Lightweight Fillant for Brick & Tile. V. 153, No. 3, September 1968, p. 26.

[15] Brick & Clay Record. Autoclaymation '69. V. 153, No. 3, September 1968, p. 44.

Table 2.—Value of clays produced in the United States, by States

(Thousand dollars)

	1967	1968	Kind of clay produced in 1968					
			Kaolin	Ball clay	Fire clay	Bentonite	Fuller's earth	Miscellaneous
Alabama	$7,422	$6,995	x		X	x		X
Arizona	[1] 37	347	x		x	x		x
Arkansas	1,740	2,134	x		x			X
California	6,037	6,630	x	x	X	x	x	X
Colorado	1,274	1,222			X	x		x
Connecticut	334	325						x
Delaware	11	12						x
Florida	11,574	11,699	x				X	x
Georgia	77,314	88,632	X				X	X
Hawaii	W	4						x
Idaho	[2,3] 16	[2,3] 14	x		x			x
Illinois	[4] 3,799	[4] 4,813			X		x	X
Indiana	2,126	2,355			x			X
Iowa	1,643	1,747						X
Kansas	1,339	1,433			x			X
Kentucky	[5] 2,066	[5] 1,952		X	X			X
Louisiana	1,260	1,163						X
Maine	54	[3] 65			x			x
Maryland	1,462	[3,5] 1,252		x	x			X
Massachusetts	W	314						x
Michigan	2,636	2,906						X
Minnesota	[3] 342	[3] 359			x			x
Mississippi	7,852	9,075		X	X	X	X	X
Missouri	6,220	6,158			X			X
Montana	[1] 50	[1] 34				x		x
Nebraska	142	206						x
New Hampshire	42	41						x
New Jersey	1,189	1,008						x
New Mexico	74	89			x			x
New York	1,814	1,790						X
North Carolina	[2] 2,012	[2] 2,148	x					X
Ohio	15,185	15,216			X			X
Oklahoma	[1] 869	[1] 967			x	x		x
Oregon	[3] 295	[3] 284			x	x		x
Pennsylvania	[2] 16,703	[2] 17,679	x		X			X
South Carolina	8,048	8,923	X					X
South Dakota	799	1,119				x		x
Tennessee	[4] 5,152	[4] 5,772		X			x	X
Texas	8,081	8,860	x	x	X	X	x	X
Utah	[2,3] 288	[2] 476	x		x	x	x	x
Virginia	1,623	1,714						X
Washington	[3] 203	[3] 213			x			x
West Virginia	[3] 254	[3] 219			X			x
Wisconsin	112	34						x
Wyoming	14,313	17,275			x	X		x
Other [6]	10,181	11,225						
Total	223,987	246,898						
Puerto Rico	244	481						x

W Withheld to avoid disclosing individual company confidential data, included in "Other."
X Major producing States which account for approximately 90 percent of production.
x Other producing States.

[1] Value of bentonite included with "Other" to avoid disclosing individual company confidential data.

[2] Value of kaolin included with "Other" to avoid disclosing individual company confidential data.

[3] Value of fire clay included with "Other" to avoid disclosing individual company confidential data.

[4] Value of fuller's earth included with "Other" to avoid disclosing individual company confidential data.

[5] Value of ball clay included with "Other" to avoid disclosing individual company confidential data.

[6] Includes Hawaii (1967), Nevada, North Dakota and Vermont, value indicated by footnote 1 through 6, and values indicated by symbol W.

Table 3.—Kaolin sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Sold by producers		Used by producers		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1964	3,120	$62,622	211	$1,985	3,331	$64,607
1965	3,214	66,058	389	3,403	3,604	69,461
1966	3,664	75,318	721	6,666	4,385	81,984
1967:						
Arizona	(1)	2	--------	--------	(1)	2
California	22	229	--------	--------	22	229
Florida and North Carolina	38	922	--------	--------	38	922
Georgia	2,680	66,209	329	3,118	3,009	69,327
South Carolina	474	6,649	67	321	540	6,970
Other States [2]	122	1,636	241	2,234	363	3,870
Total	3,336	75,647	637	5,673	3,973	81,321
1968:						
Arizona	(1)	2	--------	--------	(1)	2
California	W	W	W	W	23	292
Florida and North Carolina	39	903	--------	--------	39	903
Georgia	2,881	75,854	284	3,208	3,165	79,061
South Carolina	498	7,177	83	517	581	7,694
Other States [2]	160	2,240	256	2,586	393	4,534
Total	3,579	86,175	622	6,311	4,201	92,486

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Less than ½ unit.

[2] Includes Alabama, Arkansas, Idaho, Pennsylvania, Texas, Utah, Vermont (1967), and States indicated by symbol W.

Table 4.—Georgia kaolin sold or used by producers, by uses

(Thousand short tons and thousand dollars)

Year	China clay, paper clay, etc.	Refractory uses	Total kaolin		
				Value	
	Quantity	Quantity	Quantity	Total	Average per ton
1964	2,389	195	2,584	$54,520	21.10
1965	2,478	243	2,721	57,411	21.10
1966	2,719	487	3,206	67,156	20.95
1967	2,708	301	3,009	69,327	23.04
1968	2,947	218	3,165	79,061	24.98

Table 5.—Ball clay sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1964	567	$7,830
1965	591	8,197
1966	571	7,322
1967	559	7,446
1968	630	8,351

Table 6.—Fire clay, including stoneware clay,[1] sold or used by producers in the United States, by States

Year and State	Sold by producers		Used by producers		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value [2] (thousands)
1964	2,615,102	$9,706	5,933,588	$31,287	8,548,690	$40,993
1965	2,823,837	10,581	6,191,812	32,532	9,015,649	43,114
1966	2,596,470	8,869	6,181,695	33,311	8,778,165	42,179
1967:						
Alabama	W	W	W	W	622,484	3,856
California	W	W	W	W	420,985	1,140
Colorado	46,899	226	95,776	410	142,675	636
Illinois	92,192	892	152,170	481	244,362	1,373
Indiana	193,086	312	54,205	108	247,291	420
Kansas	W	W	W	W	142,897	312
Kentucky	W	W	W	W	144,296	926
Maine	---------	------	34	99	34	(3)
Missouri	86,666	205	1,043,907	4,542	1,130,573	4,747
Montana	119	(3)	---------	-----------	119	(2)
New Jersey	W	W	W	W	99,527	766
New Mexico	410	4	60	(3)	470	4
Ohio	839,614	2,669	1,175,025	7,561	2,014,639	10,230
Oklahoma	---------	------	376	4	376	4
Pennsylvania	489,512	1,213	945,714	9,743	1,435,226	10,956
Texas	W	W	W	W	747,909	1,862
Other States [4]	763,913	4,470	1,992,735	9,318	578,550	4,926
Total	2,512,411	[2] 9,990	5,460,002	[2] 32,168	7,972,413	42,157
1968:						
Alabama	W	W	W	W	581,699	3,082
Arizona	30	1	---------	-----------	30	1
California	126,249	284	396,154	1,051	522,403	1,335
Colorado	128,045	470	112,475	360	240,520	830
Illinois	93,013	938	153,727	528	246,740	1,466
Indiana	130,314	238	51,285	103	181,599	340
Kansas	W	W	W	W	157,848	349
Kentucky	80,573	308	115,028	643	195,601	950
Missouri	68,226	162	996,008	4,172	1,064,234	4,334
New Jersey	W	W	W	W	84,120	624
New Mexico	W	W	W	W	2,024	13
Ohio	895,986	2,901	1,117,053	7,180	2,013,039	10,081
Oklahoma	---------	------	476	5	476	5
Pennsylvania	435,852	1,073	988,160	10,244	1,424,012	11,317
Texas	W	W	W	W	766,165	1,988
Utah	W	W	W	W	11,916	42
Other States	589,590	3,299	1,575,708	8,138	561,526	5,389
Total	2,547,878	[2] 9,673	5,506,074	[2] 32,421	8,053,952	42,094

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes stoneware clay as follows, in short tons: 1964, 45,679; 1965, 49,517; 1966, 45,887; 1967, 51,579; 1968, 59,266.

[2] Data may not add to totals shown because of independent rounding.

[3] Less than ½ unit.

[4] Includes Arkansas, Idaho, Maine (1968), Maryland, Minnesota, Mississippi, Nevada (1968), Oregon, Utah (1967), Washington, West Virginia, Wyoming and States indicated by symbol W.

Table 7.—Bentonite sold or used by producers in the United States, by States

Year and State	Short tons	Value (thousands)
1964	1,729,503	$19,413
1965	1,887,947	20,407
1966	2,060,616	22,010
1967:		
Colorado	1,663	13
Mississippi	259,133	3,067
Oregon	799	10
Texas	97,211	660
Utah	2,508	25
Wyoming	1,454,670	14,223
Other States [1]	226,857	2,492
Total	2,042,841	20,490
1968:		
Arizona	28,197	$318
California	33,139	655
Colorado	1,885	18
Mississippi	277,449	3,128
Oregon	1,022	12
Texas	92,487	611
Utah	1,556	26
Wyoming	1,777,383	17,168
Other States [1]	224,408	2,044
Total	2,437,526	23,970

[1] Alabama, Arizona (1967), California (1967), Montana, Nevada, North Dakota (1967), Oklahoma, and South Dakota.

Table 8.—Fuller's earth sold or used by producers in the United States, by States

Year and State	Short tons	Value (thousands)
1964	551,886	$12,743
1965	674,422	15,795
1966	759,638	18,354
1967:		
Florida and Georgia	655,990	17,538
Utah	2,645	45
Other States [1]	145,284	2,956
Total	803,919	20,539
1968:		
Florida and Georgia	704,572	$18,609
Utah	2,993	55
Other States [1]	213,985	4,512
Total	921,550	23,176

[1] Includes California, Illinois, Mississippi, Nevada, Tennessee, and Texas.

Table 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Sold by producers		Used by producers		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1964	1,366	$1,611	36,853	$45,436	38,219	$47,046
1965	1,310	1,463	38,043	46,494	39,354	47,957
1966	1,156	1,399	39,005	48,467	40,161	49,865
1967:						
Alabama	W	W	W	W	1,917	2,173
Arizona	--------	--------	67	35	67	35
Arkansas	--------	--------	811	1,066	811	1,066
California	195	338	1,923	3,694	2,118	4,032
Colorado	73	145	380	480	452	625
Connecticut	--------	--------	191	334	191	334
Delaware	--------	--------	11	11	11	11
Georgia	--------	--------	1,673	1,094	1,673	1,094
Idaho	--------	--------	19	16	19	16
Illinois	--------	--------	1,637	2,426	1,637	2,426
Indiana	191	194	1,051	1,513	1,242	1,706
Iowa	--------	--------	1,208	1,643	1,208	1,643
Kansas	--------	--------	792	1,027	792	1,027
Kentucky	W	W	W	W	1,051	1,140
Louisiana	--------	--------	995	1,260	995	1,260
Maine	--------	--------	42	54	42	54
Maryland	W	W	W	W	970	1,145

Table 9.—Miscellaneous clay, including shale and slip clay sold or used by producers in the United States, by States—Continued

(Thousand short tons and thousand dollars)

Year and State	Sold by producers		Used by producers		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1967—Continued						
Michigan	--------	--------	2,466	$2,636	2,466	$2,636
Minnesota	--------	--------	228	342	228	342
Mississippi	--------	--------	1,089	1,479	1,089	1,479
Missouri	--------	--------	1,174	1,473	1,174	1,473
Montana	--------	--------	46	49	46	49
Nebraska	--------	--------	126	142	126	141
New Hampshire	--------	--------	42	42	42	42
New Jersey	--------	--------	338	423	338	423
New Mexico	1	$12	45	58	46	70
New York	W	W	W	W	1,506	1,814
North Carolina	--------	--------	2,977	2,012	2,977	2,012
Ohio	258	198	2,398	4,757	2,655	4,955
Oklahoma	--------	--------	744	865	744	865
Oregon	W	W	W	W	294	285
Pennsylvania	85	62	1,474	5,686	1,559	5,748
South Carolina	--------	--------	1,193	1,078	1,193	1,078
Tennessee	--------	--------	1,202	533	1,202	533
Texas	--------	--------	3,598	4,882	3,598	4,882
Utah	W	W	W	W	109	219
Virginia	--------	--------	1,382	1,623	1,382	1,623
Washington	W	W	W	W	139	203
West Virginia	W	W	W	W	245	254
Wisconsin	--------	--------	89	112	89	112
Undistributed [1]	250	318	6,852	7,923	872	1,009
Total	1,054	1,266	38,259	50,768	39,312	52,035
1968:						
Alabama	W	W	W	W	2,043	2,553
Arizona	W	W	W	W	49	26
Arkansas	--------	--------	760	1,164	760	1,164
California	346	1,295	1,806	2,911	2,153	4,206
Colorado	8	8	366	371	374	379
Connecticut	--------	--------	195	325	195	325
Delaware	--------	--------	12	12	12	12
Georgia	--------	--------	1,631	1,619	1,631	1,619
Hawaii	3	4	--------	--------	3	4
Idaho	--------	--------	12	14	12	14
Illinois	6	10	2,074	3,337	2,080	3,347
Indiana	271	403	1,098	1,612	1,369	2,015
Iowa	--------	--------	1,264	1,747	1,264	1,747
Kansas	--------	--------	774	1,084	774	1,084
Kentucky	W	W	W	W	1,023	1,002
Louisiana	--------	--------	863	1,163	863	1,163
Maine	--------	--------	42	65	42	65
Maryland	W	W	W	W	1,078	1,252
Massachusetts	--------	--------	257	314	257	314
Michigan	--------	--------	2,599	2,906	2,599	2,906
Minnesota	--------	--------	240	359	234	359
Mississippi	--------	--------	1,063	1,422	1,063	1,422
Missouri	--------	--------	1,369	1,824	1,369	1,824
Montana	--------	--------	30	34	30	34
Nebraska	--------	--------	148	206	148	206
New Hampshire	--------	--------	41	41	41	41
New Jersey	--------	--------	289	384	289	384
New Mexico	W	W	W	W	64	76
New York	W	W	W	W	1,675	1,790
North Carolina	--------	--------	3,310	2,148	3,310	2,148
Ohio	285	304	2,452	4,831	2,737	5,136
Oklahoma	--------	--------	726	963	726	963
Oregon	W	W	W	W	212	272
Pennsylvania	W	W	W	W	1,610	6,362
South Carolina	--------	--------	1,355	1,229	1,355	1,229
Tennessee	--------	--------	1,151	674	1,151	674
Texas	--------	--------	3,756	5,388	3,756	5,388
Utah	1	5	142	349	143	354
Virginia	--------	--------	1,462	1,714	1,462	1,714
Washington	W	W	W	W	140	213
West Virginia	W	W	W	W	194	219
Wisconsin	--------	--------	17	34	17	34
Undistributed [1]	537	735	8,228	13,816	677	786
Total	1,456	2,764	39,532	54,058	40,989	56,822

W Withheld to avoid disclosing individual company confidential data.

[1] Includes States indicated by symbol W and Florida, Hawaii (1967), Massachusetts (1967), Nevada, North Dakota, South Dakota, Vermont, and Wyoming.

Table 10.—Clay sold or used by producers in the United States in 1968, by kinds

(Thousand short tons)

Uses	Kaolin	Ball clay	Fire clay and stoneware clay	Bentonite	Fuller's earth	Miscellaneous clay including slip clay	Total
Pottery and stoneware:							
Whiteware, etc	[1] 112	[1] 282	------	------	------	------	[1] 394
Stoneware, art pottery, flowerpots, and glaze slip	(1)	(1)	59	------	------	60	[1] 120
Total	112	282	59	------	------	60	514
Floor and wall tile	52	143	329	------	------	53	577
Refractories:							
Firebrick and block	398	(2)	2,772	------	------	(2)	3,227
Bauxite, high-alumina brick	(2)	------	18	------	------	------	[3] 18
Fire-clay mortar	(2)	------	114	------	------	(2)	[3] 114
Clay crucibles		------	(2)	------	------	------	(2)
Glass refractories	(2)	------	(2)	------	------	------	(2)
Foundries and steelworks	(2)	(2)	485	[4] 745	------	(2)	1,234
Zinc retorts	------	------	(2)	------	------	------	(2)
Saggers, pins, stilts, and wads	(2)	(2)	(2)	------	------	------	(2)
Other refractories	70	114	341	(4)	------	52	515
Total	468	114	3,730	745	------	52	5,109
Heavy clay products: Building brick, paving brick, draintile, sewer pipe, kindred products	------	(5)	3,813	------	------	19,873	[6] 23,686
Architectural terra cotta	(5)	------	(5)	------	------	------	(5)
Lightweight aggregates	------	------	(5)	------	------	9,280	[6] 9,280
Filler:							
Paper filling	637	------	------	(2)	------	------	[3] 637
Paper coating	1,389	------	------	(2)	(5)	------	[3] 1,389
Rubber	368	------	------	------	------	------	368
Paint	127	------	------	------	------	------	127
Fertilizers	90	------	(2)	------	------	(2)	99
Insecticides and fungicides	10	------	(2)	5	148	(2)	[3] 163
Other fillers	174	(5)	10	9	(5)	19	218
Total	2,794	(5)	10	14	148	19	3,001
Portland and other hydraulic cements	63	------	(5)	(5)	------	11,222	[6] 11,284
Miscellaneous:							
Filtering, declorizing, clarifying	------	------	------	161	42	------	203
Rotary-drilling mud	------	------	(5)	533	74	3	[6] 610
Chemicals	61	------	(5)	11	(5)	------	[6] 72
Animal feed	------	------	------	47	(5)	------	[6] 47
Absorbent uses	------	------	------	(5)	601	(5)	[6] 601
Enameling	(5)	(5)	------	(5)	(5)	------	9
Catalysts (oil refining)	(5)	------	------	------	------	------	(5)
Pelletizing:							
Iron ore	------	------	------	544	------	------	544
Other	------	------	------	29	(5)	----	[6] 29
Reservoir, pond and ditch lining	------	------	------	(5)	------	------	(5)
Other uses	651	91	113	353	57	426	1,666
Total	712	91	113	1,678	773	429	3,781
Grand total:							
1968	4,201	630	8,054	2,438	922	40,989	57,233
1967	3,973	559	7,972	2,043	804	39,312	54,664

[1] Some stoneware, art pottery, etc., included with whiteware.
[2] Included with "Other."
[3] Incomplete figures; remainder included with "Other."
[4] Some "Other refractories" included with foundries.
[5] Included with miscellaneous "Other uses."
[6] Incomplete figure; remainder included with miscellaneous "Other uses."

Table 11.—Shipments of refractories in the United States, by kinds

Product	Unit of quantity	Shipments			
		1967 [r]		1968	
		Quantity	Value (thousands)	Quantity	Value (thousands)
CLAY REFRACTORIES					
Fire clay (including semisilica) brick and shapes, except superduty.	1,000 9-inch equivalent	276,969	$53,410	260,397	$50,745
Superduty fire-clay brick and shapes	do	78,456	24,296	71,075	23,152
High-alumina brick and shapes (50 percent Al_2O_3 and over) made substantially of calcined diaspore or bauxite.[1]	do	49,751	26,931	54,872	30,821
Insulating firebrick and shapes	do	59,318	17,515	50,928	15,269
Ladle brick	do	187,214	23,757	200,203	26,118
Sleeves, nozzles, runner brick, tuyeres	do	45,035	12,231	44,768	12,075
Glasshouse pots, tank blocks, feeder parts, and upper structure shapes used only for glass tanks.[1] [2]					
Hot-top refractories	Short tons	47,283	3,988	49,357	4,289
Clay-kiln furniture, radiant-heater elements, potters' supplies, and other miscellaneous shaped refractory items.		NA	7,851	NA	8,817
Refractory bonding mortars, air-setting (wet and dry types).[3]	Short tons	62,753	8,647	62,856	8,309
Refractory bonding mortars, except air-setting types.[3]	do	14,678	1,704	12,687	1,589
Ground crude fire clay, high-alumina clay, silica fire clay.	do	NA	NA	NA	NA
Plastic refractories and ramming mixes [3]	do	190,095	16,974	177,623	17,108
Castable refractories (hydraulic-setting)	do	161,779	16,496	164,512	18,613
Insulating castable refractories (hydraulic-setting)	do	39,245	5,151	37,973	5,453
Other clay refractory materials sold in lump or ground form.[4] [5]	do	225,246	6,165	281,796	7,302
Total clay refractories		XX	225,116	XX	229,660
NONCLAY REFRACTORIES					
Silica brick and shapes	1,000 9-inch equivalent	71,009	$14,668	59,568	$14,793
Magnesite and magnesite-chrome brick and shapes (magnesite predominating) (excluding molten cast and fused magnesia).	do	93,832	89,852	93,273	96,522
Chrome and chrome-magnesite brick and shapes (chrome predominating) (excluding molten cast).	do	22,221	18,860	20,312	18,391
Graphite crucibles, retorts, stopper heads, and other shaped refractories containing natural graphite.	Short tons	16,586	13,726	14,661	13,641
Mullite brick and shapes made predominantly of kyanite, sillimanite, andalusite, or synthetic mullite (excluding molten-cast).	1,000 9-inch	6,903	9,528	5,136	8,293
Extra-high alumina brick and shapes made predominantly of fused bauxite, fused or dense-sintered alumina (excluding molten-cast).	do	2,861	7,363	2,918	8,245
Silicon carbide brick and shapes made predominantly of silicon carbide (including kiln furniture).	do	3,999	12,895	3,823	11,988
Zircon and zirconia brick and shapes made predominantly of either of these materials.	do	1,486	5,397	1,722	5,480
Forsterite, pyrophyllite, molten-cast, dolomite, dolomite-magnesite, and other nonclay brick and shapes including carbon refractories except those containing natural graphite.	do	25,709	41,651	23,973	39,901
Mortars:					
Basic bonding mortars (magnesite or chrome ore predominating).	Short tons	79,886	6,634	87,433	7,746
Other nonclay refractory mortars	do	31,597	5,452	32,771	5,799
Nonclay refractory castables (hydraulic-setting)	do	31,541	6,862	33,710	7,950
Plastic refractories and ramming mixes (wet and dry types):					
Basic (magnesite, dolomite, or chrome ore predominating).	do	154,641	17,463	144,484	17,926
Other nonclay plastic refractories and ramming mixes.	do	57,628	12,612	65,825	14,455
Dead-burned magnesia or magnesite	do	100,799	6,244	118,913	7,308
Nonclay gunning mixes	do	257,217	22,245	260,188	25,270
Other nonclay refractory materials sold in lump or ground form.[4]	do	127,347	13,433	151,203	9,459
Total nonclay refractories		XX	304,885	XX	313,167
Grand total refractories		XX	530,001	XX	542,827

---

[r] Revised. NA Not available. XX Not applicable.

[1] Excludes data for mullite and extra-high alumina refractories. These products are included with mullite and extra-high alumina brick and shapes in the nonclay refractories section.

[2] Included with fireclay (including semisilica) brick and shapes, except superduty.

[3] Includes data for bonding mortars which contain up to 60 percent Al_2O_3, dry basis. Bonding mortars which contain more than 60 percent Al_2O_3, dry basis, are included in the nonclay refractories section.

[4] Represents only shipments by establishments classified in "manufacturing" industries, and excludes shipments to refractories producers for the manufacture of brick and other refractories.

[5] Includes data for calcined clay, ground brick, and siliceous and other gunning mixes.

Table 12.—Shipments of principal structural clay products in the United States

Product	1964	1965	1966	1967	1968
Unglazed brick (buildings) 1,000 standard brick	7,743,800	8,089,131	7,606,237	7,117,353	7,556,809
Value thousands	$284,600	$301,038	$292,914	$285,630	$318,365
Unglazed structural tile short tons	311,400	313,260	267,431	234,517	191,067
Value thousands	$5,400	$5,128	$5,317	$4,900	$4,169
Vitrified clay sewer pipe and fittings short tons	1,837,200	1,732,159	1,610,318	1,572,167	1,705,528
Value thousands	$104,000	$103,420	$96,707	$97,330	$109,465
Facing tile, ceramic glazed, including glazed brick 1,000-brick equivalent	332,700	307,944	292,525	230,064	211,228
Value thousands	$27,500	$25,430	$25,179	$21,274	$19,708
Facing tile unglazed and salt glazed 1,000-tile, 8- by 5- by 12-inch, equivalent	6,900	6,327	5,207	3,352	3,032
Value thousands	$1,500	$1,435	$1,284	$837	$750
Clay floor and wall tile and accessories, including quarry tile 1,000 square feet	288,800	283,385	272,688	257,532	274,512
Value thousands	$146,200	$141,739	$133,266	$128,139	$138,319
Total value thousands	$569,200	$578,190	$554,667	$538,110	$590,776

Table 13.—World production of china clay, by countries[1]

(Thousand short tons)

Country [1]	1964	1965	1966	1967	1968 p
North America:					
Mexico	71	r 89	r 108	87	83
United States [2]	3,331	3,604	4,385	3,973	4,201
South America:					
Argentina	47	80	r 81	p 72	NA
Chile	51	34	45	32	29
Colombia	89	91	r 29	12	20
Ecuador	(3)	(3)	1	(3)	1
Peru	(3)	(3)	(3)	--------	1
Europe:					
Austria (marketable)	120	116	113	108	e 110
Belgium	e 94	e 138	200	109	e 108
Bulgaria	91	105	r 103	e 103	e 103
Czechoslovakia	345	r 335	r 358	369	e 330
Denmark:					
Crude	9	8	17	17	e 17
Washed and pressed	NA	3	3	3	e 3
France [3]	317	326	480	483	474
Germany, West (marketable)	451	440	r 449	r 445	451
Greece	55	r 75	r 69	77	e 77
Hungary	55	60	68	73	73
Italy:					
Crude	107	r 119	r 97	r 97	90
Kaolinitic earth	104	r 54	40	17	e 11
Portugal	42	45	38	r 41	45
Rumania	NA	e 39	e 44	e 55	e 55
Spain (marketable)	155	162	211	e 220	e 220
Sweden	49	46	30	44	e 44
U.S.S.R. e	1,650	1,750	1,750	1,900	1,900
United Kingdom	2,277	2,474	2,813	2,278	e 3,004
Africa:					
Ethiopia	e 1	e (3)	r 8	8	14
Kenya	1	2	1	2	1
Mozambique	(3)	r (3)	(3)	1	(3)
Nigeria	(3)	(3)	(3)	(3)	(3)
Rhodesia, Southern	21	22	e 22	NA	NA
South Africa, Republic of	43	r 49	45	36	36
Swaziland	(3)	1	1	e 2	2
Tanzania	(3)	NA	(3)	(3)	1
United Arab Republic [4]	69	53	55	35	34
Asia:					
Ceylon	2	1	2	3	3
Hong Kong	6	5	6	9	6
India [5]	r 496	r 564	r 611	565	558
Japan	118	98	130	r 166	192
Korea, South	67	80	124	113	133
Lebanon	NA	NA	NA	3	--------
Malaysia	2	2	2	2	2
Pakistan	r 1	r 2	r 3	3	3
Taiwan e	47	56	65	67	NA
Vietnam, South	2	NA	NA	NA	NA
Oceania: Australia [6]	51	67	56	74	e 72
Total [7]	r 10,437	r 11,195	r 12,663	11,704	NA

e Estimate. p Preliminary. r Revised. NA Not available.

[1] China clay is also produced in Brazil, China (mainland), East Germany, Israel, Thailand, and Yugoslavia, but data on production are not available; a negligible quantity is produced in Malagasy Republic and Paraguay.

[2] Kaolin sold or used by producers.

[3] Less than ½ unit.

[4] Includes kaolinitic clay.

[5] Total crude production, including clay saleable as produced and clay requiring further processing to make it of saleable grade.

[6] Includes ball clay.

[7] Total is of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/52

Coal—Bituminous and Lignite

By W. H. Young [1] and J. J. Gallagher [2]

The demand for bituminous coal and lignite outran production in 1968. U.S. bituminous coal and lignite consumption plus exports increased in 1968 to 549.5 million tons, a gain of 19.5 million tons, or 3.7 percent over that of 1967. Production, however, declined 7.4 million tons, or 1.3 percent from the 1967 level, to 545.2 million tons. This situation reflected slower business activity early in the year and a series of strikes in the final quarter of the year, which prevented producers from mining enough coal to meet the total demand.

Bituminous coal and lignite consumption increased by 18,414,000 tons principally as a result of the alltime high consumption by electric utilities. To compensate for the difference between production and demand consumers were forced to dip into their stockpiles. This reduced the stock level improvement that occurred in 1967 and reduced stocks at year end to 85.5 million tons, compared with 93.1 million tons a year earlier.

---

[1] Assistant chief, Section of Fuels, Division of Statistics.

[2] Supervisory industry economist, Division of Mineral Studies.

Table 1.—Salient statistics of the bituminous coal and lignite industry in the United States

Item	1964	1965	1966	1967	1968
Production thousand short tons	486,998	512,088	533,881	552,626	545,245
Value thousands	$2,165,582	$2,276,022	$2,421,293	$2,555,378	$2,546,340
Consumption thousand short tons	431,116	459,164	486,266	480,416	498,830
Stocks at end of year:					
Industrial consumers and retail yards thousand short tons	75,342	77,393	74,466	93,128	85,525
Stocks on upper lake docks do	2,598	2,347	2,342	2,280	1,937
Exports [1] do	47,969	50,181	49,302	49,528	50,637
Imports [1] do	293	184	178	227	224
Price indicators, average per net ton:					
Cost of coking coal at merchant coke ovens	$9.85	$9.65	$9.81	$10.33	$10.58
Railroad freight charge [2]	$3.11	$3.13	$3.01	$3.00	$3.01
Value f.o.b. mines (sold in open market)	$4.11	$4.13	$4.24	$4.34	$4.38
Value f.o.b. mines	$4.45	$4.44	$4.54	$4.62	$4.67
Method of mining:					
Hand loaded underground thousand short tons	40,707	36,028	28,243	19,219	14,755
Mechanically loaded underground thousand short tons	281,101	296,633	310,281	329,914	329,387
Percentage mechanically loaded	87.4	89.2	91.7	94.5	95.7
Percentage cut by machine	57.4	53.9	51.0	49.1	48.4
Mined by stripping thousand short tons	151,859	165,241	180,058	187,134	185,836
Percentage mined by stripping	31.2	32.3	33.7	33.9	34.1
Mined at auger mines thousand short tons	13,331	14,186	15,299	16,360	15,267
Percentage mined at auger mines	2.7	2.8	2.9	3.0	2.8
Mechanically cleaned thousand short tons	310,203	332,226	340,626	349,402	340,923
Percentage mechanically cleaned	63.7	64.9	63.8	63.2	62.5
Number of mines	7,630	7,228	6,749	5,873	5,327
Capacity at 280 days thousand short tons	606,000	655,000	683,000	707,000	NA
Average number of men working daily [3]	128,698	133,782	131,752	131,523	NA
Average number of days worked [3]	225	219	219	219	NA
Average days lost per man on strike [4]	6	4	7	3	NA
Production per man per day short tons	16.84	17.52	18.52	19.17	NA
Production per man per year do	3,784	3,829	4,052	4,198	NA

NA Not available.

[1] Bureau of the Census, U.S. Department of Commerce.

[2] Interstate Commerce Commission.

[3] Based on data supplied by Accident Analysis Branch, U.S. Bureau of Mines.

[4] Bureau of Labor Statistics, U.S. Department of Labor.

Increases in mine mechanization took place in 1968 and helped hold prices down, although there were price increases averaging $0.05 per ton resulting from general market firming and the wage increase in October.

A modest gain of 1.1 million tons, primarily in shipments to Canada, was achieved by exports during 1968, raising the total for the year to 50.6 million tons. In overseas markets, Japan increased purchases significantly while the European Coal & Steel Community reduced its total.

Coal research moved ahead in pollution, synthetic fuels, and mine safety, with industry and Government making major contributions.

In transportation, a new coal pipeline in the Far West moved closer to reality as the project passed through the initial planning and design steps to the construction stage. Unit-train shipments continued to grow.

Faced with the need for manning significant additions to industry producing capacity to meet growing requirements, the coal industry and many individual companies, aided by the Federal Government, the States, and private organizations stepped up both recruiting and training efforts. In West Virginia, one company reported a need for 1,500 men for four new mines under construction in 1968 and a total of 5,000 men for all of its operations in the State within the next 5 years.

This chapter includes all coal produced in the United States except Pennsylvania anthracite, lignite produced in Texas, and bituminous coal and lignite from mines that produced less than 1,000 tons during the year. All tonnage figures refer to marketable coal and exclude washery and other refuse. Information on employment and output per man in 1968 will be published as a supplement to the Mineral Industry Survey, the Weekly Coal Report, and in the 1969 Minerals Yearbook.

DISTRIBUTION AND SHIPMENTS

Shipments of bituminous coal and lignite, summarized by districts of origin, States of destination, type of consumer use and by methods of transportation, show the participation of the bituminous coal and lignite industry in various energy markets of the Nation, both locally and nationally.

The distribution data by consumer use do not necessarily conform to the consumption data because the latter represent actual use at consumers' facilities whereas the distribution data represent shipments from the mines, some of which were in transit or in consumers' storage.

Total shipments in 1968 declined 1.3 percent from those in 1967, with most geographic divisions sharing in the decrease. The greatest declines in quantity were in the Middle Atlantic, New England, East North Central, and East South Central geographic divisions. Increased shipments were made to West North Central, West South Central, and Mountain areas. Of the total 7.3 million ton decrease in shipments in 1968, coke and gas plants were down 3.3 million tons, retail dealers were down 1.1 million tons, "all others" declined 2.9 million tons, and overseas exports were lower by 200,000 tons. Miscellaneous items such as railroad fuel, mine fuel, employees' coal, Canadian and United States Great Lakes dock storage accounts, U.S. tidewater dock storage accounts, and net change in mine inventory were down 1 million tons. Electric utilities received 1.2 million tons more coal in 1968 than in 1967.

The quantitative changes in total tons shipped, expressed in indexes, that took place throughout the country, by geographic division, State or destination, and consumer use, are shown for the years 1957 and 1964 through 1968 in table 44. The year 1957 is used as the base year, and represents 100. For example, 1957 (base year) shipments of bituminous coal and lignite in the United States amounted to 493,895,000 tons. Total shipments in 1964 represented 98.3 percent of the 1957 level, while in 1965 total shipments, compared with 1957 figures, amounted to 103.8 percent. In 1968 they represented 110.4 percent.

To indicate the size of the bituminous coal and lignite market, quantitatively, in each geographic division, State, and consumer use category, the 1957 total tons shipped are shown in lieu of the index numbers of 100 which each tonnage figure represents (except those otherwise noted).

These distribution data are based on reports submitted quarterly, to the Bureau of Mines voluntarily by producers, sales agents, distributors, and wholesalers who normally produce or sell 100,000 tons or more annually. The unprecedented cooperation of these respondents resulted in their reporting about 94 percent of all coal produced or shipped. To account for total industry shipments, estimates for the remaining shipments are included, based on data from coal trade and other reliable coal statistical reporting agencies.

Additional details of bituminous coal and lignite distribution for 1968 are presented in a Bureau of Mines report.[3]

FOREIGN TRADE

United States imported only 224,000 tons of bituminous coal and lignite in 1968, almost identical to the quantity imported in 1967. Except for 100 tons, all coal imported in 1968 was produced in Canada.

Following World War II bituminous coal exports became an important item of foreign trade, contributing heavily to our international balance of payments.

In 1968 the United States continued to be the largest coal exporter in the world. Total exports rose to 50.6 million tons and were valued at $496 million, increases of 1.1 million tons and $21 million. Nearly 95 percent of U.S. exports in 1968 were shipped to Canada, Japan, and Europe. Most of the remaining 5 percent went to Brazil, Argentina, Chile, and Uruguay.

The sizable increase in coal exports to East Europe was one of the noteworthy developments in export trade during 1968. Shipments of coal to the "iron curtain" countries during 1968 reached 184,130 tons, all destined for East Germany and Rumania; 1967 exports to these East bloc countries totaled only 77,345 tons.

While coal exports fluctuated widely prior to 1961 because of various emergencies abroad, since then, with no major fuel emergencies, exports have increased. There is reason to believe that, because of its high quality and competitive price, U.S. coal will continue to meet an integral part of the coal supply in Canada, Japan, and Europe.

WORLD REVIEW

World production of coal totaled 3,086,438,000 tons in 1968, an increase of 3 percent over the revised total of 1967. The United States supplied nearly 557 million tons of bituminous coal, anthracite, and lignite, or 18 percent of the world output in 1968.

North America's contribution to world output declined 1.4 percent from the 1967 level. The production of all other continents increased. South America rose 1.5 percent; Europe increased 0.3 percent; Africa was up 4.7 percent; Asia showed the greatest increase, amounting to 19 percent; Oceania was second best with a gain of 8.5 percent.

Production in the U.S.S.R., the largest coal-producing country in the world, was estimated at 655 million tons in 1968, a decline of 0.2 percent from the revised 1967 tonnage.

TECHNOLOGY

Development in the coal industry during 1968 included improvements in face and haulage equipment, electrical distribution systems, and safety aids. These developments provide for more efficient operations with increases in production.

Among the developments is a specially designed bent, oscillating-head miner that makes it possible for the operator to keep the cutting bits out of the roof when the coal seam turns downhill. Significant savings in bit cost and greater productive face time are achieved.

Shuttle cars continue to be the number one haulage unit at the face. Further improvements in face haulage were made through the development of the electric-wheel shuttle car. Features on the new car include larger capacity, faster discharge rate, and greater traction on wet, uneven bottom. Also, better traction has been achieved through the use of extra-wide tires on conventional shuttle cars. Results of the new developments show less waiting time at the face and a corresponding increase in production.

---

[3] Bureau of Mines. Bituminous Coal and Lignite Distribution Calendar Year 1968. Mineral Industry Survey, March 1969, 39 pp.

At a few mines, where battery-powered tractors and trailers are used to transport men, supplies, and coal, emphasis has been placed on maintaining a smooth, dust-free haulway. A miniature tractor-towed grader is used to clean and smooth the haul roads, while a battery-powered end loader is used to pick up the loose material. Also a tractor-towed sprinkler is used to control the dust. One mine used concrete to pave its haulways in areas where soft, wet, and uneven bottoms occurred. A special container with a built-in agitator and designed to fit inside a coal trailer is under development. This new development will be used to transport the concrete underground and will aid in the paving of future trouble spots. Well-maintained haulways resulted in a smoother, faster, safer, and efficient transportation of men and material with less wear and tear on the equipment.

Longwall mining continued to increase. Fifteen units were operating in early 1968 with additional units scheduled to start before yearend. Face lengths now range from 300 to 650 feet.

The trend toward alternating current (ac) power is accelerating. Seventy-five percent of all new equipment sold in 1968 was ac powered. The ability to perform most machine functions hydraulically has led to the use of highly efficient ac motors. The capabilities of starting ac motors "across the line" has reduced the complexity of the electric controller, thereby reducing a possible trouble source.

In West Virginia, a silicon-diode controller is being tested on a loader. Reportedly the controller will reduce maintenance problems associated with other controllers. This could be a breakthrough to a near trouble-free controller and thus contribute to more productive time at the face.

Vacuum circuit breakers have proven their reliability for electric branch-circuit protection. They are readily adaptable to thin coal seams and may be installed in any position. The vacuum breaker contains no oil; therefore, fire hazards are eliminated. This alone could make the vacuum breaker a competitor of the oil breaker.

New insulation materials, including cross-link polyethylene in the jacket, played a significant role in the development of a 25-kilovolt electrical cable system at a large surface mine in the Midwest. The higher voltage resulted in a smaller cable and a greater ease of handling.

A new railroad car scanning and recording system was installed at one mine in the Midwest, and is being used in connection with unit train shipments. The scanner picks up information that has been coded on the side of the railroad car and records this information on a tape along with the weights of the payload. The information is transmitted to the computer center. The computer, in turn, can locate any car or train at any time, eliminating the possibility of cars going astray.

The field of safety continues to search for new aids that will make the Nation's coal mines safer. Methane monitors are becoming more common in gassy mines. Researchers are now developing another detector devise that can be fastened to a worker's belt and will give an audible alarm if the oxygen content drops below normal. This could be a safety booster for the mine worker.

Ventilation at the face has been aided by the design and use of auxiliary fans, both electrical and hydraulic powered fans being in use. Electric fans with 10 to 15 horsepower and having tube lengths up to 200 feet are in use. The hydraulic fans are mounted on the face machine and depend on the mining machines for power. These aids provide for a safer atmosphere at the face.

Emphasis on the environmental aspects of coal mining and utilization is continuing. The U.S. Department of Health, Education and Welfare has entered into a contract with several groups for the purpose of studying ways to reduce and eliminate air pollution. The Bureau of Mines is engaged in these efforts through a study of the availability of low sulfur coals in the Appalachian Region.

Research continued in coal utilization, with several projects advancing to a pilot plant scale. The following pilot plants were operating or started up in 1968: The coal-to-gasoline plant in West Virginia; a fly-ash construction materials plant in West Virgina; and a sewage treatment plant in Ohio wherein coal is used as a trickling medium. There are other pilot plants in the planning stages and should be coming on line soon.

Table 2.—Production of bituminous coal and lignite in the United States, by States, with estimates by months[1]

(Thousand short tons)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total[2]
1967													
Alabama	1,348	1,186	1,476	1,288	1,458	1,279	840	1,393	1,260	1,390	1,317	1,251	15,486
Alaska	99	93	101	73	54	38	58	55	80	89	86	99	925
Arizona	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1
Arkansas	22	17	18	17	16	15	14	15	12	13	15	15	189
Colorado	560	469	472	364	463	384	265	419	427	529	546	541	5,439
Illinois	5,664	5,245	6,058	5,326	5,798	5,232	4,471	5,685	5,225	5,614	5,681	5,134	65,133
Indiana	1,513	1,447	1,755	1,532	1,625	1,434	1,238	1,666	1,664	1,715	1,653	1,530	18,772
Iowa	66	84	64	75	54	93	63	88	85	79	70	62	883
Kansas	86	96	115	81	112	92	78	142	90	87	75	82	1,136
Kentucky:													
Eastern	4,413	3,699	4,402	4,536	5,078	4,797	3,957	5,340	4,598	4,693	4,580	3,811	53,904
Western	4,200	3,698	4,070	3,700	3,877	3,536	3,020	4,178	3,836	4,252	4,297	3,726	46,390
Total	8,613	7,397	8,472	8,236	8,955	8,333	6,977	9,518	8,434	8,945	8,877	7,537	100,294
Maryland	101	91	97	120	120	130	90	120	111	109	111	105	1,305
Missouri	359	308	260	287	322	322	308	348	291	293	292	306	3,696
Montana:													
Bituminous	4	4	4	3	4	2	2	4	3	4	4	4	42
Lignite	31	30	33	22	30	20	19	28	26	27	30	33	329
Total	35	34	37	25	34	22	21	32	29	31	34	37	371
New Mexico	282	256	318	298	260	249	201	340	368	321	273	297	3,463
North Dakota (lignite)	460	323	302	201	255	240	225	298	290	493	551	518	4,156
Ohio	3,176	2,874	3,692	4,123	4,570	4,415	3,691	4,542	3,689	4,050	3,932	3,260	46,014
Oklahoma	77	70	77	75	76	57	46	57	48	58	84	98	823
Pennsylvania	7,178	6,716	6,772	6,552	6,868	6,441	4,859	7,202	6,610	7,106	6,552	6,556	79,412
South Dakota (lignite)	1	1	1	-------	-------	-------	-------	-------	-------	-------	1	1	5
Tennessee	603	522	615	586	627	592	468	669	579	582	529	460	6,832
Utah	461	357	316	361	380	295	134	334	356	384	395	402	4,175
Virginia	3,055	2,761	3,216	2,924	3,236	2,981	2,773	3,363	3,173	3,224	3,213	2,802	36,721
Washington	11	9	6	4	3	2	1	1	2	4	6	10	59
West Virginia	13,484	12,343	13,858	12,546	14,364	12,433	9,973	14,495	12,518	13,307	12,669	11,759	153,749
Wyoming	398	274	258	218	191	227	176	252	264	412	479	439	3,588
Total[2]	47,652	42,973	48,356	45,312	49,841	45,306	36,970	51,034	45,605	48,835	47,441	43,302	552,626
1968													
Alabama	1,322	1,463	1,525	1,519	1,602	1,201	1,116	1,597	1,452	888	1,336	1,419	16,440
Alaska	98	90	67	52	57	45	50	43	53	58	60	77	750
Arkansas	19	15	17	19	16	12	18	19	17	18	19	22	211
Colorado	554	497	450	418	464	384	361	450	450	462	491	577	5,558
Illinois	5,671	5,477	5,587	5,723	5,555	4,727	5,049	5,689	5,327	4,400	4,958	4,278	62,441
Indiana	1,718	1,589	1,599	1,585	1,532	1,317	1,264	1,471	1,606	1,475	1,667	1,663	18,486

See footnotes at end of table.

Table 2.—Production of bituminous coal and lignite in the United States, by States, with estimates by months [1]—Continued

(Thousand short tons)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total [2]
1968—Continued													
Iowa	76	51	33	59	75	71	74	81	95	104	85	72	876
Kansas	116	90	117	127	136	104	98	130	77	98	80	95	1,268
Kentucky:													
Eastern	4,139	3,987	4,527	4,395	4,868	4,367	4,414	5,013	4,903	4,920	4,600	4,508	54,641
Western	3,977	4,188	4,251	3,900	4,122	3,311	3,666	4,055	3,920	2,866	3,599	4,660	46,515
Total	8,116	8,175	8,778	8,295	8,990	7,678	8,080	9,068	8,823	7,786	8,199	9,168	101,156
Maryland	143	137	118	117	111	120	111	132	131	118	93	116	1,447
Missouri	330	269	270	345	306	270	337	340	297	143	154	145	3,205
Montana:													
Bituminous	19	17	13	16	20	21	13	5	16	17	16	16	189
Lignite	34	29	22	29	35	37	23	8	27	30	27	29	330
Total	53	46	35	45	55	58	36	13	43	47	43	45	519
New Mexico	350	282	284	296	302	309	339	344	287	188	174	274	3,429
North Dakota (lignite)	478	368	387	320	284	244	336	325	348	400	470	527	4,487
Ohio	3,216	3,303	4,109	4,394	4,458	4,033	3,888	4,904	4,431	3,306	4,241	4,040	48,323
Oklahoma	130	121	106	98	87	89	76	94	90	67	63	68	1,089
Pennsylvania	6,338	6,294	6,988	7,130	6,993	5,627	5,838	6,912	6,582	4,993	6,264	6,242	76,200
Tennessee	521	591	638	610	722	658	763	849	697	753	659	687	8,148
Utah	444	362	330	334	382	301	268	404	403	329	378	381	4,316
Virginia	3,058	2,993	3,250	3,188	3,337	2,860	3,054	3,225	3,121	2,967	2,881	3,032	36,966
Washington	10	68	69	4	3	2	1	2	2	4	5	8	178
West Virginia	12,470	11,857	13,054	13,467	13,924	10,924	11,203	13,684	13,034	8,640	11,859	11,805	145,921
Wyoming	445	274	248	237	227	175	235	259	344	466	433	486	3,829
Total [2]	45,676	44,412	48,059	48,382	49,618	41,209	42,595	50,035	47,710	37,710	44,612	45,227	545,245

---

[1] Figures are based principally upon railroad carloadings and shipments on the Allegheny and Monongahela Rivers, supplemented by direct reports from certain local sources. These estimates include coal both shipped by truck, and used at the mines, and the totals represent output for all mines producing 1,000 tons or more per year.

[2] Data may not add to totals shown because of independent rounding.

Table 3.—Production of bituminous coal and lignite in the United States, by districts,[1] with estimates by months [2]

(Thousand short tons)

District	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total [3]
1967													
1. Eastern Pennsylvania	3,796	3,544	3,607	3,495	3,676	3,453	2,596	3,881	3,504	3,754	3,477	3,467	42,200
2. Western Pennsylvania	3,737	3,497	3,526	3,411	3,576	3,353	2,530	3,750	3,441	3,700	3,411	3,418	41,345

3.	Northern West Virginia	4,278	3,937	4,453	3,946	4,452	3,959	2,992	4,369	3,763	4,026	3,792	3,686	47,653
4.	Ohio	3,176	2,874	3,692	4,123	4,570	4,415	3,691	4,542	3,689	4,050	3,932	3,260	46,014
5.	Michigan	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
6.	Panhandle	590	543	615	545	614	546	413	603	519	555	523	509	6,575
7.	Southern Numbered 1	3,468	3,162	3,542	3,247	3,742	3,201	2,679	3,840	3,339	3,528	3,387	3,054	40,189
8.	Southern Numbered 2	12,801	11,307	13,049	12,460	14,062	12,701	10,782	14,614	12,865	13,299	12,920	11,239	152,099
9.	West Kentucky	4,200	3,698	4,070	3,700	3,877	3,536	3,020	4,178	3,836	4,252	4,297	3,726	46,390
10.	Illinois	5,664	5,245	6,058	5,326	5,798	5,232	4,471	5,685	5,225	5,614	5,681	5,134	65,133
11.	Indiana	1,513	1,447	1,755	1,532	1,625	1,434	1,238	1,666	1,664	1,715	1,653	1,530	18,772
12.	Iowa	66	84	64	75	54	93	63	88	85	79	70	62	883
13.	Southeastern	1,512	1,328	1,644	1,448	1,629	1,440	968	1,575	1,418	1,549	1,461	1,376	17,348
14.	Arkansas-Oklahoma	50	43	47	45	44	36	31	36	30	35	46	51	494
15.	Southwestern	494	448	423	415	482	450	415	526	411	416	420	450	5,350
16.	Northern Colorado	93	71	70	44	45	33	3	36	43	65	76	93	672
17.	Southern Colorado	521	447	463	377	468	399	301	448	455	526	522	505	5,432
18.	New Mexico	228	207	257	241	210	201	162	275	297	259	221	241	2,799
19.	Wyoming	398	274	258	218	191	227	176	252	264	412	479	439	3,588
20.	Utah	461	357	316	361	380	295	134	334	356	384	395	402	4,175
21.	North-South Dakota	461	324	303	201	255	240	225	298	290	493	552	519	4,161
22.	Montana	35	34	37	25	34	22	21	32	29	31	34	37	371
23.	Washington	110	102	107	77	57	40	59	56	82	93	92	109	984
	Total [3]	47,652	42,973	48,356	45,312	49,841	45,306	36,970	51,034	45,605	48,835	47,441	43,302	552,626
	1968													
1.	Eastern Pennsylvania	3,487	3,446	3,785	3,854	3,787	3,083	3,174	3,757	3,585	2,714	3,363	3,373	41,408
2.	Western Pennsylvania	3,279	3,256	3,615	3,689	3,618	2,911	3,020	3,576	3,405	2,584	3,240	3,229	39,422
3.	Northern West Virginia	3,869	3,689	3,998	4,016	4,101	3,361	3,325	3,929	3,777	2,530	3,346	3,319	43,260
4.	Ohio	3,216	3,303	4,109	4,394	4,458	4,033	3,888	4,904	4,431	3,306	4,241	4,040	48,323
5.	Michigan	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
6.	Panhandle	621	593	642	645	659	540	534	631	607	406	538	533	6,949
7.	Southern Numbered 1	3,185	3,029	3,362	3,505	3,654	2,817	2,955	3,634	3,449	2,341	3,183	3,188	38,302
8.	Southern Numbered 2	12,111	11,713	13,030	13,061	13,974	11,696	12,203	14,097	13,488	11,647	12,538	12,593	152,151
9.	West Kentucky	3,977	4,188	4,251	3,900	4,122	3,311	3,666	4,055	3,920	2,866	3,599	4,660	46,515
10.	Illinois	5,671	5,477	5,587	5,723	5,555	4,727	5,049	5,689	5,327	4,400	4,958	4,278	62,441
11.	Indiana	1,718	1,589	1,599	1,585	1,532	1,317	1,264	1,471	1,606	1,475	1,667	1,663	18,486
12.	Iowa	76	51	33	59	75	71	74	81	95	104	85	72	876
13.	Southeastern	1,439	1,596	1,668	1,656	1,764	1,349	1,288	1,788	1,609	1,057	1,484	1,574	18,272
14.	Arkansas-Oklahoma	63	56	53	52	45	42	44	51	47	41	40	45	579
15.	Southwestern	532	439	457	537	500	433	485	532	434	285	276	285	5,195
16.	Northern Colorado	90	75	49	44	42	29	5	43	59	65	71	82	654
17.	Southern Colorado	542	485	464	440	489	424	432	484	455	439	459	556	5,670
18.	New Mexico	272	219	221	230	235	240	263	267	223	146	135	213	2,664
19.	Wyoming	445	274	248	237	227	175	235	259	344	466	433	486	3,829
20.	Utah	444	362	330	334	382	301	268	404	403	329	378	381	4,316
21.	North-South Dakota	478	368	387	320	284	244	336	325	348	400	470	527	4,487
22.	Montana	53	46	35	45	55	58	36	13	43	47	43	45	519
23.	Washington	108	158	136	56	60	47	51	45	55	62	65	85	928
	Total [3]	45,676	44,412	48,059	48,382	49,618	41,209	42,595	50,035	47,710	37,710	44,612	45,227	545,245

---

[1] Districts as defined in the Coal Act of 1937 and modifications thereto.

[2] Figures are based principally upon railroad carloadings and shipments on the Allegheny and Monongahela Rivers, supplemented by direct reports from certain local sources. These estimates include coal both shipped by truck, and used at the mines, and the totals represent output for all mines producing 1,000 tons or more per year.

[3] Data may not add to totals shown because of independent rounding.

Table 4.—Production of bituminous coal and lignite in the United States, with estimates by weeks

(Thousand short tons)

1967				1968			
Week ended—	Production	Maximum number of working days	Average production per working day	Week ended—	Production	Maximum number of working days	Average production per working day
Jan. 7	9,673	5	1,935	Jan. 6	8,443	5	1,689
Jan. 14	11,302	6	1,884	Jan. 13	10,177	6	1,696
Jan. 21	11,186	6	1,864	Jan. 20	10,275	6	1,713
Jan. 28	11,313	6	1,886	Jan. 27	10,929	6	1,822
Feb. 4	10,851	6	1,809	Feb. 3	8,672	6	1,445
Feb. 11	10,569	6	1,762	Feb. 10	10,769	6	1,795
Feb. 18	11,161	6	1,860	Feb. 17	11,058	6	1,843
Feb. 25	10,675	6	1,779	Feb. 24	10,802	6	1,800
Mar. 4	10,656	6	1,776	Mar. 2	11,337	6	1,888
Mar. 11	9,223	6	1,537	Mar. 9	11,370	6	1,895
Mar. 18	10,484	6	1,739	Mar. 16	10,928	6	1,821
Mar. 25	10,968	6	1,828	Mar. 23	11,309	6	1,885
Apr. 1	11,225	5.5	2,041	Mar. 30	12,078	6	2,013
Apr. 8	10,945	6	1,824	Apr. 6	9,727	5.3	1,835
Apr. 15	11,218	6	1,870	Apr. 13	11,447	6	1,908
Apr. 22	11,426	6	1,904	Apr. 20	11,520	6	1,920
Apr. 29	11,468	6	1,911	Apr. 27	11,554	6	1,926
May 6	11,402	6	1,900	May 4	11,064	6	1,844
May 13	11,121	6	1,854	May 11	11,384	6	1,897
May 20	10,950	6	1,825	May 18	11,101	6	1,850
May 27	11,670	6	1,945	May 25	11,149	6	1,858
June 3	9,622	5.1	1,887	June 1	9,583	5.1	1,879
June 10	11,577	6	1,930	June 8	11,664	6	1,944
June 17	11,546	6	1,924	June 15	11,707	6	1,951
June 24	11,529	6	1,922	June 22	11,664	6	1,944
July 1	6,028	2.4	2,512	June 29	5,645	2.7	2,091
July 8	3,977	1.5	2,651	July 6	4,025	1.7	2,368
July 15	9,748	4.5	2,166	July 13	9,969	4.7	2,121
July 22	9,549	5.2	1,836	July 20	10,778	5.7	1,891
July 29	11,309	6	1,885	July 27	11,386	6	1,898
Aug. 5	11,023	6	1,837	Aug. 3	11,084	6	1,847
Aug. 12	11,219	6	1,870	Aug. 10	11,149	6	1,858
Aug. 19	11,171	6	1,862	Aug. 17	11,250	6	1,875
Aug. 26	10,992	6	1,832	Aug. 24	11,417	6	1,903
Sept. 2	11,335	6	1,889	Aug. 31	11,572	6	1,929
Sept. 9	9,473	5	1,895	Sept. 7	9,725	5	1,945
Sept. 16	11,243	6	1,874	Sept. 14	11,596	6	1,933
Sept. 23	11,144	6	1,857	Sept. 21	11,607	6	1,935
Sept. 30	11,128	6	1,855	Sept. 28	12,309	6	2,052
Oct. 7	11,034	6	1,839	Oct. 5	8,415	6	1,403
Oct. 14	11,110	6	1,852	Oct. 12	4,674	6	779
Oct. 21	11,024	6	1,837	Oct. 19	7,332	6	1,222
Oct. 28	11,361	6	1,894	Oct. 26	10,914	6	1,819
Nov. 4	11,018	6	1,836	Nov. 2	11,597	6	1,933
Nov. 11	11,054	5.6	1,974	Nov. 9	11,008	6	1,835
Nov. 18	11,481	6	1,914	Nov. 16	9,898	5.3	1,868
Nov. 25	9,568	5	1,914	Nov. 23	11,343	6	1,891
Dec. 2	11,163	6	1,861	Nov. 30	9,614	5	1,923
Dec. 9	11,154	6	1,859	Dec. 7	10,489	6	1,748
Dec. 16	10,665	6	1,778	Dec. 14	11,251	6	1,875
Dec. 23	10,649	6	1,775	Dec. 21	11,084	6	1,847
Dec. 30	8,297	5	1,659	Dec. 28	8,038	5	1,608
				Jan. 4	[1] 4,365	[1] 2	[2] 1,743
Total [3]	552,626	295.8	1,868	Total [3]	545,245	298.5	1,827

---

[1] Figures represent output and number of working days in that part of week included in calendar year shown. Total production for the week ending Jan. 4, 1969, was 8,715,000 short tons.

[2] Average daily output for the entire week and not for working days in the calendar year shown.

[3] Data may not add to totals shown because of independent rounding.

Table 5.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal and lignite mines in the United States, in 1967, by districts

District	Number of active mines	Production (thousand short tons)				Average value per ton [4]	Average number of men working daily	Average number of days worked	Number of man-days worked (thousands)	Average tons per man per day
		Shipped by rail or water [1]	Shipped by truck	Used at mine [2]	Total [3]					
1. Eastern Pennsylvania	699	31,525	9,204	1,470	42,200	$4.44	11,209	236	2,646	15.95
2. Western Pennsylvania	268	33,824	6,702	819	41,345	5.99	11,709	231	2,706	15.28
3. Northern West Virginia	393	46,728	917	7	47,653	4.76	11,675	220	2,568	18.56
4. Ohio	401	29,457	13,720	2,837	46,014	3.84	7,505	248	1,864	24.69
5. Michigan	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
6. Panhandle	19	3,839	312	2,424	6,575	4.38	1,480	244	361	18.20
7. Southern Numbered 1	505	39,328	703	159	40,189	6.34	14,052	213	2,995	13.42
8. Southern Numbered 2	2,965	143,888	7,805	406	152,099	4.65	48,606	195	9,485	16.04
9. West Kentucky	78	39,711	6,678	-----	46,390	3.42	5,073	255	1,295	35.84
10. Illinois	75	56,776	5,241	3,117	65,133	3.88	7,988	268	2,143	30.40
11. Indiana	48	13,930	2,414	2,429	18,772	3.91	1,851	266	493	38.08
12. Iowa	17	622	261	-----	883	3.66	201	208	42	21.13
13. Southeastern	213	13,862	2,773	713	17,348	6.86	5,510	218	1,201	14.44
14. Arkansas-Oklahoma	11	494	-----	-----	494	7.51	224	147	33	14.97
15. Southwestern	26	3,475	517	1,357	5,350	4.35	687	268	184	29.08
16. Northern Colorado	5	438	230	5	672	4.16	211	194	41	16.41
17. Southern Colorado	61	4,170	1,119	143	5,432	5.26	1,279	224	287	18.93
18. New Mexico	6	353	2,447	-----	2,799	2.57	156	244	38	73.66
19. Wyoming	14	1,471	54	2,063	3,588	3.31	316	225	71	50.44
20. Utah	24	3,723	425	27	4,175	5.82	1,238	210	261	16.02
21. North-South Dakota	25	2,623	392	1,146	4,161	1.92	308	211	65	64.02
22. Montana	12	330	41	-----	371	2.68	72	148	11	34.88
23. Washington	8	931	49	4	983	7.94	173	254	44	22.35
Total [3]	5,873	471,497	62,003	19,127	552,626	4.62	131,523	219	28,833	19.17

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.

[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

[3] Data may not add to totals shown because of independent rounding.

[4] Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.

Table 6.—Number of mines, production, value, men working daily, days active, man-days, and output per man per day at bituminous coal and lignite mines in the United States, in 1968, by districts

District	Number of active mines	Production (thousand short tons)				Average value per ton [4]
		Shipped by rail or water [1]	Shipped by truck	Used at mine [2]	Total [3]	
1. Eastern Pennsylvania	643	28,725	10,037	2,647	41,408	$4.52
2. Western Pennsylvania	240	32,312	6,405	705	39,422	6.09
3. Northern West Virginia	342	42,004	1,251	4	43,260	4.82
4. Ohio	372	32,328	13,129	2,866	48,323	3.96
5. Michigan	--------	--------	--------	--------	--------	--------
6. Panhandle	17	4,383	255	2,311	6,949	4.42
7. Southern Numbered 1	479	37,226	904	172	38,302	6.39
8. Southern Numbered 2	2,659	144,476	7,323	352	152,151	4.70
9. West Kentucky	84	40,159	6,347	8	46,515	3.42
10. Illinois	70	53,635	5,677	3,129	62,441	4.01
11. Indiana	44	13,659	2,352	2,475	18,486	3.88
12. Iowa	15	612	264	--------	876	3.75
13. Southeastern	193	14,686	2,858	729	18,272	6.71
14. Arkansas-Oklahoma	12	571	3	4	579	7.82
15. Southwestern	20	3,586	378	1,232	5,195	4.51
16. Northern Colorado	4	445	207	2	654	4.25
17. Southern Colorado	52	4,494	1,094	83	5,670	5.37
18. New Mexico	4	389	2,275	--------	2,664	2.66
19. Wyoming	13	1,571	51	2,207	3,829	3.16
20. Utah	23	3,878	421	17	4,316	5.77
21. North-South Dakota	22	2,950	315	1,221	4,487	1.78
22. Montana	11	484	35	--------	519	2.34
23. Washington	8	755	172	1	928	5.74
Total [3]	5,327	463,328	61,753	20,165	545,245	4.67

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.

[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

[3] Data may not add to totals shown because of independent rounding.

[4] Value received or charged for coal, f.o.b. mine. Includes a value, estimated by producer, for coal not sold.

Table 7.—Number and production of bituminous coal and lignite mines in the United States, in 1967, by States, size of output, and type of mining

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Alabama:														
Underground	6	6,922	4	1,598	1	117	3	166	19	313	58	246	91	9,362
Strip	2	1,549	5	1,414	11	1,525	13	931	21	581	10	43	62	6,043
Auger	-------	-------	-------	-------	-------	-------	-------	-------	2	72	2	9	4	81
Total [1]	8	8,471	9	3,012	12	1,641	16	1,097	42	966	70	299	157	15,486
Alaska: Strip	-------	-------	3	921	-------	-------	-------	-------	-------	-------	1	4	4	925
Arizona: Underground	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1	1	1
Arkansas:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	2	44	1	1	3	45
Strip	-------	-------	-------	-------	-------	-------	1	73	3	71	-------	-------	4	144
Total [1]	-------	-------	-------	-------	-------	-------	1	73	5	114	1	1	7	189
Colorado:														
Underground	2	1,433	4	1,101	4	421	2	172	15	341	28	106	55	3,574
Strip	2	1,305	1	495	-------	-------	1	54	-------	-------	3	7	7	1,862
Auger	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	4	1	4
Total [1]	4	2,738	5	1,597	4	421	3	226	15	341	32	117	63	5,439
Illinois:														
Underground	15	26,419	2	694	4	529	2	141	6	155	3	10	32	27,948
Strip	24	34,976	3	987	7	1,051	1	90	5	67	3	13	43	37,185
Total [1]	39	61,396	5	1,680	11	1,580	3	232	11	222	6	24	75	65,133
Indiana:														
Underground	1	986	1	331	1	114	2	142	5	66	1	2	11	1,641
Strip	11	15,439	3	1,120	1	159	2	122	11	246	9	46	37	17,131
Total [1]	12	16,426	4	1,451	2	272	4	263	16	312	10	48	48	18,772
Iowa:														
Underground	-------	-------	-------	-------	2	286	-------	-------	-------	-------	3	9	5	295
Strip	-------	-------	-------	-------	1	117	5	356	4	104	2	11	12	588
Total [1]	-------	-------	-------	-------	3	403	5	356	4	104	5	20	17	883

See footnote at end of table.

Table 7.—Number and production of bituminous coal and lignite mines in the United States, in 1967, by States, size of output, and type of mining—Continued

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Kansas: Strip	1	882	-------	-------	1	185	1	60	-------	-------	2	9	5	1,136
Kentucky:														
Underground	28	28,121	26	7,839	37	5,064	74	5,020	438	9,734	681	2,740	1,284	58,518
Strip	16	28,799	9	2,756	17	2,366	13	907	32	880	17	77	104	35,785
Auger	-------	-------	2	520	15	1,921	23	1,693	67	1,673	37	183	144	5,990
Total [1]	44	56,920	37	11,115	69	9,351	110	7,621	537	12,288	735	2,999	1,532	100,294
Maryland:														
Underground	-------	-------	-------	-------	2	214	-------	-------	6	128	11	39	19	381
Strip	-------	-------	1	208	-------	-------	6	405	9	200	15	67	31	880
Auger	-------	-------	-------	-------	-------	-------	-------	-------	1	30	2	16	3	45
Total [1]	-------	-------	1	208	2	214	6	405	16	358	28	121	53	1,305
Missouri:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	1	1	1
Strip	3	3,075	1	408	-------	-------	1	52	5	143	3	16	13	3,694
Total [1]	3	3,075	1	408	-------	-------	1	52	5	143	4	17	14	3,696
Montana:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	1	12	8	30	9	42
Strip	-------	-------	1	327	-------	-------	-------	-------	-------	-------	2	2	3	329
Total [1]	-------	-------	1	327	-------	-------	-------	-------	1	12	10	32	12	371
New Mexico:														
Underground	1	660	-------	-------	-------	-------	-------	-------	-------	-------	4	9	5	668
Strip	1	2,435	1	349	-------	-------	-------	-------	1	11	-------	-------	3	2,795
Total [1]	2	3,095	1	349	-------	-------	-------	-------	1	11	4	9	8	3,463
North Dakota: Strip	3	2,983	2	729	1	137	3	201	3	53	12	52	24	4,156
Ohio:														
Underground	10	12,890	5	1,482	-------	-------	6	433	13	243	33	124	67	15,172
Strip	14	13,594	18	5,687	29	3,908	49	3,353	97	2,375	66	292	273	29,209
Auger	-------	-------	-------	-------	3	423	5	315	35	809	18	86	61	1,633
Total [1]	24	26,483	23	7,169	32	4,332	60	4,100	145	3,428	117	502	401	46,014

Oklahoma:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	2	1	2
Strip	-------	-------	1	430	2	301	-------	-------	3	81	3	7	9	819
Auger	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	2	1	2
Total [1]	-------	-------	1	430	2	301	-------	-------	3	81	5	11	11	823
Pennsylvania:														
Underground	40	40,493	24	7,787	31	4,948	14	1,060	66	1,704	137	496	312	56,490
Strip	2	1,396	7	2,011	34	4,480	108	7,549	220	5,837	146	712	517	21,984
Auger	-------	-------	-------	-------	1	110	1	59	31	619	29	150	62	938
Total [1]	42	41,889	31	9,798	66	9,537	123	8,669	317	8,160	312	1,358	891	79,412
South Dakota: Strip	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	5	1	5
Tennessee:														
Underground	1	621	1	283	8	1,241	11	672	36	826	69	310	126	3,954
Strip	-------	-------	-------	-------	8	991	13	894	25	721	12	71	58	2,677
Auger	-------	-------	-------	-------	-------	-------	1	59	4	120	4	22	9	202
Total [1]	1	621	1	283	16	2,232	25	1,625	65	1,667	85	404	193	6,832
Utah: Underground	2	1,302	4	1,502	7	1,032	3	219	3	90	5	31	24	4,175
Virginia:														
Underground	10	10,890	17	5,234	8	1,073	43	2,888	411	9,043	295	1,372	784	30,500
Strip	-------	-------	4	991	11	1,546	12	959	23	620	20	80	70	4,196
Auger	-------	-------	-------	-------	3	514	10	710	27	660	24	141	64	2,025
Total [1]	10	10,890	21	6,226	22	3,133	65	4,557	461	10,823	339	1,593	918	36,721
Washington:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	1	39	2	17	3	56
Strip	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	3	1	3
Total [1]	-------	-------	-------	-------	-------	-------	-------	-------	1	39	3	20	4	59
West Virginia:														
Underground	82	86,436	84	26,863	67	9,503	64	4,443	284	6,875	489	2,073	1,070	136,193
Strip	1	512	4	1,343	34	5,294	28	1,999	101	2,720	49	249	217	12,117
Auger	-------	-------	3	663	15	2,111	21	1,498	41	1,022	29	147	109	5,440
Total [1]	83	86,949	91	28,869	116	16,908	113	7,939	426	10,617	567	2,468	1,396	153,749
Wyoming:														
Underground	-------	-------	-------	-------	1	106	-------	-------	-------	-------	4	11	5	117
Strip	3	2,460	3	938	-------	-------	-------	-------	2	70	1	3	9	3,471
Total [1]	3	2,460	3	938	1	106	-------	-------	2	70	5	14	14	3,588
United States:														
Underground	198	217,173	172	54,714	173	24,648	224	15,356	1,306	29,613	1,835	7,630	3,908	349,133
Strip	83	109,405	67	21,114	157	22,060	257	18,005	565	14,780	378	1,769	1,507	187,134
Auger	-------	-------	5	1,183	37	5,079	61	4,344	208	5,005	147	760	458	16,360
Total [1]	281	326,578	244	77,011	367	51,787	542	37,695	2,079	49,398	2,360	10,159	5,873	552,626

[1] Data may not add to totals shown because of independent rounding.

Table 8.—Number and production of bituminous coal and lignite mines in the United States, in 1968, by States, size of output, and type of mining

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Alabama:														
Underground	6	6,926	4	1,640	1	148	1	56	19	276	49	207	80	9,252
Strip	2	1,784	5	1,531	15	2,092	17	1,224	17	467	4	28	60	7,125
Auger	-------	-------	-------	-------	-------	-------	-------	-------	2	63	-------	-------	2	63
Total [1]	8	8,709	9	3,171	16	2,240	18	1,280	38	805	53	235	142	16,440
Alaska: Strip	-------	-------	2	746	-------	-------	-------	-------	-------	-------	1	4	3	750
Arkansas:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	2	59	-------	-------	2	59
Strip	-------	-------	-------	-------	-------	-------	2	124	1	19	3	9	6	152
Total [1]	-------	-------	-------	-------	-------	-------	2	124	3	78	3	9	8	211
Colorado:														
Underground	2	1,448	4	1,187	4	577	3	225	14	236	22	91	49	3,763
Strip	3	1,695	-------	-------	-------	-------	1	69	1	31	-------	-------	5	1,795
Total [1]	5	3,143	4	1,187	4	577	4	294	15	267	22	91	54	5,558
Illinois:														
Underground	15	24,442	4	1,119	4	508	2	148	7	170	1	3	33	26,392
Strip	21	33,025	6	2,523	2	232	2	160	4	91	1	8	36	36,039
Auger	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	10	1	10
Total [1]	36	57,468	10	3,642	6	740	4	308	11	262	3	21	70	62,441
Indiana:														
Underground	2	1,875	-------	-------	1	115	1	74	5	104	-------	-------	9	2,168
Strip	10	14,131	5	1,654	1	135	3	177	9	198	7	24	35	16,318
Total [1]	12	16,006	5	1,654	2	250	4	251	14	302	7	24	44	18,486
Iowa:														
Underground	-------	-------	-------	-------	2	289	-------	-------	-------	-------	1	4	3	293
Strip	-------	-------	-------	-------	-------	-------	5	409	6	169	1	6	12	584
Total [1]	-------	-------	-------	-------	2	289	5	409	6	169	2	9	15	876
Kansas: Strip	1	978	1	280	-------	-------	-------	-------	-------	-------	2	11	4	1,268
Kentucky:														
Underground	31	30,439	28	8,978	31	4,068	90	6,416	364	8,200	577	2,592	1,121	60,694

Strip	16	27,143	9	2,822	13	1,712	16	1,285	46	1,166	23	105	123	34,233
Auger	-------	-------	2	568	14	1,692	25	1,758	74	2,021	36	190	151	6,229
Total [1]	47	57,582	39	12,368	58	7,472	131	9,459	484	11,387	636	2,887	1,395	101,156
Maryland:														
Underground	-------	-------	-------	-------	1	113	1	88	4	105	15	48	21	354
Strip	-------	-------	-------	-------	-------	-------	8	599	13	354	12	41	33	994
Auger	-------	-------	-------	-------	-------	-------	-------	-------	4	80	3	19	7	99
Total [1]	-------	-------	-------	-------	1	113	9	687	21	539	30	108	61	1,447
Missouri: Strip	3	2,590	1	464	-------	-------	-------	-------	6	145	2	6	12	3,205
Montana:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	2	22	5	14	7	36
Strip	-------	-------	1	329	1	151	-------	-------	-------	-------	2	3	4	483
Total [1]	-------	-------	1	329	1	151	-------	-------	2	22	7	17	11	519
New Mexico:														
Underground	1	763	-------	-------	-------	-------	-------	-------	-------	-------	2	5	3	768
Strip	1	2,265	1	387	-------	-------	-------	-------	-------	-------	1	9	3	2,662
Total [1]	2	3,028	1	387	-------	-------	-------	-------	-------	-------	3	14	6	3,429
North Dakota: Strip	3	3,432	2	670	2	244	1	54	3	40	11	45	22	4,487
Ohio:														
Underground	11	13,327	7	2,515	-------	-------	3	206	13	229	21	61	55	16,339
Strip	14	14,669	16	5,507	36	5,170	39	2,918	79	1,854	79	398	263	30,516
Auger	-------	-------	-------	-------	2	266	6	431	32	704	14	67	54	1,468
Total [1]	25	27,996	23	8,021	38	5,436	48	3,556	124	2,787	114	526	372	48,323
Oklahoma:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	1	31	-------	-------	1	31
Strip	1	638	-------	-------	2	330	1	51	1	30	1	2	6	1,052
Auger	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	1	6	1	6
Total [1]	1	638	-------	-------	2	330	1	51	2	61	2	8	8	1,089
Pennsylvania:														
Underground	38	39,192	26	8,613	26	3,906	18	1,189	56	1,365	97	357	261	54,622
Strip	2	1,229	8	2,324	36	4,990	60	4,334	265	7,437	118	598	489	20,912
Auger	-------	-------	-------	-------	-------	-------	2	139	16	330	37	198	55	667
Total [1]	40	40,421	34	10,937	62	8,896	80	5,662	337	9,131	252	1,153	805	76,200
Tennessee:														
Underground	1	731	4	1,335	8	1,028	10	606	32	670	59	255	114	4,624
Strip	-------	-------	1	206	9	1,154	21	1,392	18	477	10	63	59	3,292
Auger	-------	-------	-------	-------	-------	-------	1	60	8	172	-------	-------	9	232
Total [1]	1	731	5	1,540	17	2,182	32	2,058	58	1,319	69	318	182	8,148
Utah: Underground	3	2,011	4	1,253	4	580	4	311	5	154	3	7	23	4,316

See footnote at end of table.

Table 8.—Number and production of bituminous coal and lignite mines in the United States, in 1968, by States, size of output, and type of mining—Continued

(Thousand short tons)

State	500,000 tons and over		200,000 to 500,000 tons		100,000 to 200,000 tons		50,000 to 100,000 tons		10,000 to 50,000 tons		Less than 10,000 tons		Total [1]	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity
Virginia:														
Underground	14	14,253	9	2,388	24	3,262	36	2,404	346	7,938	229	1,154	658	31,400
Strip	-------	-------	4	1,200	6	917	11	785	49	1,064	16	80	86	4,046
Auger	-------	-------	-------	-------	1	127	8	538	39	772	17	83	65	1,520
Total [1]	14	14,253	13	3,588	31	4,306	55	3,727	434	9,775	262	1,317	809	36,966
Washington:														
Underground	-------	-------	-------	-------	-------	-------	-------	-------	1	31	2	19	3	50
Strip	-------	-------	-------	-------	1	125	-------	-------	-------	-------	1	3	2	128
Total [1]	-------	-------	-------	-------	1	125	-------	-------	1	31	3	22	5	178
West Virginia:														
Underground	70	76,482	95	30,328	66	10,056	61	4,423	256	5,941	386	1,637	934	128,866
Strip	1	836	7	2,317	23	3,128	50	3,480	80	2,029	59	291	220	12,081
Auger	-------	-------	1	228	12	1,601	24	1,756	49	1,262	23	126	109	4,974
Total [1]	71	77,318	103	32,873	101	14,785	135	9,659	385	9,233	468	2,054	1,263	145,921
Wyoming:														
Underground	-------	-------	-------	-------	1	106	-------	-------	-------	-------	3	10	4	117
Strip	3	2,634	3	1,008	-------	-------	-------	-------	2	69	1	2	9	3,713
Total [1]	3	2,634	3	1,008	1	106	-------	-------	2	69	4	12	13	3,829
United States:														
Underground	194	211,889	185	59,356	173	24,756	230	16,146	1,127	25,531	1,472	6,464	3,381	344,142
Strip	81	107,049	72	23,968	147	20,380	237	17,061	600	15,640	355	1,736	1,492	185,836
Auger	-------	-------	3	796	29	3,686	66	4,682	224	5,404	132	699	454	15,267
Total [1]	275	318,938	260	84,118	349	48,822	533	37,890	1,951	46,576	1,959	8,898	5,327	545,245

---

[1] Data may not add to totals shown because of independent rounding.

Table 9.—Production of bituminous coal and lignite in the United States, by districts and by underground, strip and auger mining

(Thousand short tons)

District	1967				1968			
	Underground	Strip	Auger	Total [1]	Under ground	Strip	Auger	Total [1]
1. Eastern Pennsylvania	28,242	18,192	766	42,200	22,798	18,009	600	41,408
2. Western Pennsylvania	35,532	5,588	226	41,345	34,312	4,944	166	39,422
3. Northern West Virginia	42,234	5,091	328	47,653	38,262	4,785	213	43,260
4. Ohio	15,172	29,209	1,633	46,014	16,339	30,516	1,468	48,323
5. Michigan	------	------	------	------	------	------	------	------
6. Panhandle	6,435	110	30	6,575	6,818	99	32	6,949
7. Southern Numbered 1	36,415	2,996	778	40,189	34,644	3,084	574	38,302
8. Southern Numbered 2	125,097	14,521	12,482	152,099	124,775	15,457	11,919	152,151
9. West Kentucky	16,077	30,282	31	46,390	17,866	28,432	216	46,515
10. Illinois	27,948	37,185	------	65,133	26,392	36,039	10	62,441
11. Indiana	1,641	17,131	------	18,772	2,168	16,318	------	18,486
12. Iowa	295	588	------	883	293	584	------	876
13. Southeastern	10,365	6,902	81	17,348	10,337	7,873	63	18,272
14. Arkansas-Oklahoma	46	445	2	494	90	482	6	579
15. Southwestern	1	5,348	------	5,350	------	5,195	------	5,195
16. Northern Colorado	672	------	------	672	654	------	------	654
17. Southern Colorado	3,566	1,862	4	5,432	3,875	1,795	------	5,670
18. New Mexico	4	2,795	------	2,799	2	2,662	------	2,664
19. Wyoming	117	3,471	------	3,588	117	3,713	------	3,829
20. Utah	4,175	------	------	4,175	4,316	------	------	4,316
21. North-South Dakota	------	4,161	------	4,161	------	4,487	------	4,487
22. Montana	42	329	------	371	36	483	------	519
23. Washington	56	927	------	983	50	878	------	928
Total [1]	349,133	187,134	16,360	552,626	344,142	185,836	15,267	545.245

[1] Data may not add to totals shown because of independent rounding.

Table 10.—Underground mine data for bituminous

(Thousand

State	Number of mines	Production	Cut by hand and shot from solid	Cut by machines			Mined by continuous mining machines
				Quantity	Number of coal cutting machines	Average output per machine	
1967							
Alabama	91	9,362	135	8,943	117	76	284
Arizona	1	1	1	--------	--------	--------	--------
Arkansas	3	45	--------	45	8	6	--------
Colorado	55	3,574	13	942	70	13	2,617
Illinois	32	27,948	--------	12,800	60	213	15,038
Indiana	11	1,641	--------	1,592	23	69	49
Iowa	5	295	1	293	7	42	--------
Kentucky	1,284	58,518	3,435	45,889	1,033	44	9,195
Maryland	19	381	17	247	18	14	116
Missouri	1	2	--------	1	1	1	--------
Montana	9	42	1	41	12	3	--------
New Mexico	5	668	4	4	2	2	660
Ohio	67	15,172	2	6,678	100	67	8,492
Oklahoma	1	2	--------	2	1	2	--------
Pennsylvania	312	56,490	99	9,727	326	30	45,843
Tennessee	126	3,954	398	3,043	122	25	513
Utah	24	4,175	3	958	27	35	2,882
Virginia	784	30,500	3,175	17,741	589	30	9,065
Washington	3	56	56	1	--------	--------	--------
West Virginia	1,070	136,193	1,457	62,466	1,130	55	70,817
Wyoming	5	117	--------	117	17	7	--------
Total [1]	3,908	349,138	8,798	171,530	3,663	47	165,571
1968							
Alabama	80	9,252	211	8,658	111	78	383
Arkansas	2	59	--------	59	6	10	--------
Colorado	49	3,768	6	971	62	16	2,786
Illinois	33	26,392	--------	12,224	61	200	14,168
Indiana	9	2,168	--------	1,989	21	95	179
Iowa	3	293	--------	293	5	59	--------
Kentucky	1,121	60,694	4,762	45,388	805	56	10,544
Maryland	21	354	14	244	21	12	95
Montana	7	36	--------	36	10	4	--------
New Mexico	3	768	2	3	1	3	763
Ohio	55	16,339	6	6,858	78	85	9,475
Oklahoma	1	31	--------	--------	--------	--------	31
Pennsylvania	261	54,622	72	9,544	262	36	43,391
Tennessee	114	4,624	355	3,663	115	32	606
Utah	23	4,316	3	881	25	35	3,149
Virginia	658	31,400	2,509	17,489	496	35	10,411
Washington	3	50	50	--------	--------	--------	--------
West Virginia	934	128,866	1,159	58,126	970	60	67,835
Wyoming	4	117	--------	117	11	11	--------
Total [1]	3,381	344,142	9,149	166,543	3,060	54	163,816

---

[1] Data may not add to totals shown because of independent rounding.

coal and lignite mines in the United States, by States

short tons)

Mined by longwall machines	Number of mines using power drills	Number of power drills and production							
		Face or coal drills				Roof or rock drills			
		Handheld and post mounted		Mobile		Roof bolting		Other uses	
		Number	Quantity	Number	Quantity	Rotary	Percussion	Rotary	Percussion
--------	77	150	5,646	30	3,435	54	36	21	20
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
--------	3	8	45	--------	--------	--------	--------	3	--------
--------	44	64	240	7	317	11	35	--------	3
110	32	5	39	84	12,761	168	--------	2	--------
--------	11	9	167	13	1,425	16	1	--------	2
--------	4	3	4	3	286	3	--------	1	--------
--------	1,079	1,294	23,740	222	25,300	391	74	9	15
--------	14	23	248	--------	--------	4	--------	1	--------
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
--------	9	13	32	1	10	--------	--------	--------	--------
--------	3	5	4	--------	--------	6	8	--------	--------
--------	57	61	1,390	29	5,279	106	4	3	--------
--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
820	210	286	3,206	37	6,511	310	267	21	60
--------	103	211	3,060	5	320	18	2	1	1
331	22	7	40	23	913	4	54	--------	7
518	704	959	15,652	28	5,016	96	104	4	10
--------	3	14	56	--------	--------	--------	--------	--------	--------
1,453	912	1,415	30,928	221	32,063	860	250	43	72
--------	5	8	115	1	2	4	--------	--------	--------
3,232	3,292	4,535	84,612	704	93,638	2,051	835	109	190
--------	64	112	4,601	39	4,224	46	39	4	35
--------	2	6	59	--------	--------	1	--------	1	--------
--------	39	52	226	8	348	12	33	--------	--------
--------	32	2	31	88	12,193	185	--------	1	--------
--------	9	7	145	13	1,844	25	1	--------	2
--------	2	--------	--------	2	289	3	--------	--------	--------
--------	973	1,123	21,879	241	27,930	436	86	5	8
--------	15	25	244	--------	--------	8	2	--------	--------
--------	7	9	26	1	10	--------	--------	--------	--------
--------	1	3	2	--------	--------	1	3	--------	--------
--------	47	38	326	39	6,530	105	2	2	--------
--------	1	--------	--------	--------	--------	--------	2	--------	--------
1,615	172	199	2,653	34	6,836	301	263	19	77
--------	86	159	3,737	3	214	21	4	--------	1
282	24	6	20	21	864	11	35	--------	--------
990	604	812	14,809	28	5,089	130	92	--------	6
--------	3	12	50	--------	--------	--------	--------	--------	--------
1,746	734	1,052	24,075	241	34,139	873	221	29	56
--------	4	10	113	1	4	4	--------	--------	--------
4,633	2,819	3,627	72,996	759	100,514	2,162	783	61	185

Table 11.—Haulage units and length of rail track in use in bituminous coal and lignite underground mines in the United States, by States

State	Locomotives			Tractors, rubber-tired	Mine cars		Shuttle cars		Shuttle buggies	Gathering and haulage conveyors		Rail track reported (miles)		
	Trolley	Battery	All others		Rail	Rubber-tired	Cable reel	Battery		Units	Miles	Main line	All other	Total
1967														
Alabama	129	------	------	21	2,042	------	156	------	------	72	28.3	82.6	35.0	117.6
Arkansas	------	1	------	------	22	------	------	------	------	------	------	.6	------	.6
Colorado	77	14	------	4	2,315	------	113	16	1	30	9.3	32.9	12.9	45.8
Illinois	85	18	------	16	1,556	8	310	4	------	171	73.2	34.5	19.5	54.0
Indiana	13	------	------	------	159	------	37	------	------	11	5.7	7.9	1.8	9.7
Iowa	6	------	------	------	287	------	5	------	------	------	------	3.7	1.0	4.7
Kentucky	528	62	7	889	6,298	1,324	718	150	512	296	108.7	226.9	81.2	308.1
Maryland	------	2	------	3	52	13	4	------	23	14	2.8	2.3	2.5	4.8
Missouri	------	------	------	------	------	------	------	------	1	------	------	------	------	------
Montana (bituminous)	8	2	1	------	135	------	9	1	------	------	------	3.5	.1	3.6
New Mexico	------	1	------	2	6	------	10	------	------	4	2.8	.3	------	.3
Ohio	184	8	1	14	3,221	14	180	------	4	95	31.3	88.5	25.1	113.6
Oklahoma	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Pennsylvania	1,069	77	6	106	15,634	131	950	22	25	574	180.1	473.4	289.4	762.8
Tennessee	74	12	------	51	564	84	40	2	22	27	5.4	30.5	9.9	40.4
Utah	101	4	------	5	2,347	11	116	2	------	60	19.5	73.6	16.4	90.0
Virginia	158	18	------	1,089	2,731	3,406	206	56	27	183	86.6	116.0	35.4	151.4
Washington	3	------	------	------	13	1	1	------	------	------	------	.7	------	.7
West Virginia	1,277	33	42	478	32,966	1,333	2,130	97	402	1,244	402.2	787.0	297.6	1,084.6
Wyoming	------	------	------	------	------	------	7	------	------	7	1.4	------	------	------
Total	3,712	252	57	2,678	70,348	6,325	4,992	350	1,017	2,788	957.3	1,964.9	827.8	2,792.7
1968														
Alabama	115	------	------	48	2,082	------	149	------	------	79	31.6	79.2	33.2	112.4
Arkansas	------	1	------	------	10	------	------	------	------	------	------	.5	------	.5
Colorado	66	16	------	1	2,161	------	122	11	------	28	11.9	29.3	14.2	43.5
Illinois	82	23	------	20	1,490	1	363	13	------	214	86.7	38.6	21.5	60.1
Indiana	12	------	------	------	143	------	38	------	------	11	5.7	8.3	1.0	9.3
Iowa	6	------	------	------	120	------	5	------	------	------	------	2.8	3.0	5.8
Kentucky	369	31	1	916	5,581	1,164	700	132	437	353	138.2	183.8	67.8	251.6
Maryland	------	2	------	3	60	13	4	------	22	7	1.4	2.5	2.5	5.0
Montana (bituminous)	6	1	1	------	129	------	5	------	------	------	------	2.1	2.5	4.6
New Mexico	------	1	------	2	5	------	8	------	------	5	1.9	.3	------	.3
Ohio	173	5	4	1	3,022	6	199	2	------	103	36.6	80.6	25.1	105.7
Oklahoma	------	------	------	------	------	------	2	------	------	------	------	------	------	------
Pennsylvania	1,054	61	5	75	15,292	108	969	31	15	578	191.8	490.4	259.3	749.7
Tennessee	72	13	------	58	411	75	67	2	29	41	19.6	25.1	5.7	30.8
Utah	77	5	------	11	1,974	11	101	5	2	56	17.1	45.3	17.2	62.5
Virginia	147	23	------	960	2,442	2,756	218	41	21	240	105.2	99.2	34.5	133.7
Washington	3	------	------	------	13	1	1	------	------	------	------	.7	------	.7
West Virginia	1,245	26	54	450	30,715	1,128	2,101	68	260	1,250	408.4	749.6	306.3	1,055.9
Wyoming	------	------	------	------	------	------	7	------	------	4	1.1	------	------	------
Total	3,427	208	65	2,545	65,650	5,263	5,059	305	786	2,969	1,057.2	1,838.3	793.8	2,632.1

Table 12.—Method of haulage at bituminous coal and lignite underground mines in the United States, by States

(Thousand short tons)

State	Production from mines 1967					
	Reporting rail mine cars	Reporting rubber-tired mine cars	Reporting shuttle buggies	With conveyor haulage only	Not reporting type of haulage	Total [1]
1967						
Alabama	4,643	----------	----------	3,980	739	9,362
Arizona	----------	----------	----------	----------	1	1
Arkansas	23	----------	----------	----------	22	45
Colorado	1,398	----------	7	1,754	415	3,574
Illinois	7,181	7	----------	19,889	871	27,948
Indiana	311	----------	----------	1,318	12	1,641
Iowa	295	----------	----------	----------	----------	295
Kentucky	19,384	9,613	1,936	19,000	8,585	58,518
Maryland	19	45	86	228	3	381
Missouri	----------	----------	1	----------	----------	1
Montana:						
Bituminous	37	----------	----------	----------	4	41
Lignite	----------	----------	----------	----------	1	1
Total	37	----------	----------	----------	5	42
New Mexico	3	----------	----------	660	5	668
Ohio	12,708	13	5	2,409	37	15,172
Oklahoma	----------	----------	----------	----------	2	2
Pennsylvania	33,718	302	47	18,366	4,057	56,490
Tennessee	2,102	638	43	619	552	3,954
Utah	3,076	21	----------	1,064	14	4,175
Virginia	6,680	7,509	109	7,435	8,767	30,500
Washington	48	8	----------	----------	----------	56
West Virginia	91,178	4,876	1,215	35,016	3,908	186,193
Wyoming	----------	----------	----------	107	10	117
Total [1]	182,804	23,033	3,448	111,845	28,003	349,133
1968						
Alabama	4,629	----------	----------	4,144	479	9,252
Arkansas	31	----------	----------	----------	28	59
Colorado	1,706	----------	----------	1,237	820	3,763
Illinois	5,872	----------	----------	19,866	654	26,392
Indiana	293	----------	----------	1,875	----------	2,168
Iowa	293	----------	----------	----------	----------	293
Kentucky	18,056	5,245	1,521	23,800	12,072	60,694
Maryland	15	48	75	210	6	354
Montana:						
Bituminous	24	----------	----------	----------	12	36
Lignite	----------	----------	----------	----------	----------	----------
Total	24	----------	----------	----------	12	36
New Mexico	2	----------	----------	763	3	768
Ohio	11,824	4	----------	4,419	92	16,339
Oklahoma	----------	----------	----------	----------	31	31
Pennsylvania	34,908	84	54	19,308	268	54,622
Tennessee	1,445	267	41	1,354	1,517	4,624
Utah	2,914	21	115	1,227	39	4,316
Virginia	6,839	7,715	58	11,346	5,442	31,400
Washington	41	9	----------	----------	----------	50
West Virginia	86,787	3,366	1,224	34,762	2,727	128,866
Wyoming	----------	----------	----------	106	11	117
Total [1]	175,679	16,758	3,088	124,417	24,201	344,142

---

[1] Data may not add to totals shown because of independent rounding.

Table 13.—Rail mine cars used and haulage at bituminous coal and lignite underground mines in the United States, by States

State	Capacity							Production, by size of mine car reported (thousand short tons)						
	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total [1]	1 ton	2 tons	3 tons	4–5 tons	6–9 tons	10 tons and over	Total [1]
1967														
Alabama	24	19	33	630	1,336	-------	2,042	16	5	77	991	3,554	-------	4,643
Arkansas	12	-------	-------	10	-------	-------	22	1	-------	-------	22	-------	-------	23
Colorado	88	1,537	181	379	130	-------	2,315	48	563	14	387	385	-------	1,398
Illinois	106	482	80	203	601	84	1,556	52	493	225	951	3,871	1,588	7,181
Indiana	-------	138	-------	21	-------	-------	159	-------	230	-------	81	-------	-------	311
Iowa	197	-------	90	-------	-------	-------	287	9	-------	286	-------	-------	-------	295
Kentucky	97	618	945	2,341	1,286	1,011	6,298	48	1,004	2,438	4,046	4,982	6,864	19,384
Maryland	52	-------	-------	-------	-------	-------	52	19	-------	-------	-------	-------	-------	19
Montana: Bituminous	-------	84	35	16	-------	-------	135	-------	29	4	4	-------	-------	37
New Mexico	6	-------	-------	-------	-------	-------	6	3	-------	-------	-------	-------	-------	3
Ohio	150	147	55	696	976	1,197	3,221	73	61	89	1,995	2,975	7,515	12,708
Pennsylvania	849	2,263	1,485	897	6,808	3,337	15,634	203	923	1,380	1,448	17,946	11,819	33,718
Tennessee	99	58	140	240	27	-------	564	68	83	541	1,146	264	-------	2,102
Utah	-------	21	-------	1,279	1,047	-------	2,347	-------	13	-------	1,638	1,424	-------	3,076
Virginia	10	176	605	1,390	-------	550	2,731	8	174	1,769	2,069	-------	2,659	6,680
Washington	-------	-------	-------	13	-------	-------	13	-------	-------	-------	48	-------	-------	48
West Virginia	127	1,194	7,527	11,642	3,754	8,722	32,966	81	1,026	10,384	21,744	12,689	45,255	91,178
Total [1]	1,817	6,737	11,176	19,757	15,960	14,901	70,848	629	4,604	17,207	36,570	48,090	75,700	182,804
1968														
Alabama	-------	19	180	520	985	378	2,082	-------	6	315	920	2,436	952	4,629
Arkansas	-------	-------	-------	10	-------	-------	10	-------	-------	-------	31	-------	-------	31
Colorado	94	1,402	181	384	-------	100	2,161	48	495	16	465	-------	683	1,706
Illinois	81	446	80	201	592	90	1,490	51	380	225	946	2,388	1,882	5,872
Indiana	-------	110	12	21	-------	-------	143	-------	184	35	74	-------	-------	293
Iowa	60	-------	60	-------	-------	-------	120	4	-------	289	-------	-------	-------	293
Kentucky	15	343	718	2,247	550	1,708	5,581	34	713	2,243	3,807	2,582	8,678	18,056
Maryland	52	8	-------	-------	-------	-------	60	14	2	-------	-------	-------	-------	15
Montana: Bituminous	-------	67	42	-------	-------	20	129	-------	8	14	-------	-------	2	24
New Mexico	5	-------	-------	-------	-------	-------	5	2	-------	-------	-------	-------	-------	2
Ohio	88	152	60	571	976	1,175	3,022	30	69	71	1,568	2,863	7,225	11,824
Pennsylvania	514	1,489	1,324	799	7,112	4,054	15,292	584	482	1,586	780	17,243	14,233	34,908
Tennessee	43	54	102	212	-------	-------	411	31	88	560	766	-------	-------	1,445
Utah	-------	21	-------	1,654	299	-------	1,974	-------	13	-------	2,015	886	-------	2,914
Virginia	30	136	471	1,305	200	300	2,442	18	88	1,372	2,379	1,627	1,356	6,839
Washington	-------	-------	-------	13	-------	-------	13	-------	-------	-------	41	-------	-------	41
West Virginia	90	757	5,997	11,386	3,622	8,863	30,715	58	741	8,216	21,032	13,768	42,972	86,787
Total [1]	1,072	5,004	9,227	19,328	14,336	16,688	65,650	874	3,269	14,942	34,824	43,793	77,983	175,679

[1] Data may not add to totals shown because of independent rounding.

Table 14.—Rubber-tired mine cars used and haulage at bituminous coal and lignite underground mines in the United States, by States

State	Capacity							Production, by size of mine car reported (thousand short tons)						
	1 ton	2 tons	3 tons	4-5 tons	6-9 tons	10 tons and over	Total [1]	1 ton	2 tons	3 tons	4-5 tons	6-9 tons	10 tons and over	Total [1]
1967														
Illinois	-------	2	-------	6	-------	-------	8	-------	2	-------	4	-------	-------	7
Kentucky	167	490	417	232	11	7	1,324	581	1,952	2,391	3,095	1,595	-------	9,618
Maryland	-------	13	-------	-------	-------	-------	13	-------	45	-------	-------	-------	-------	45
Ohio	-------	6	2	6	-------	-------	14	-------	6	7	-------	-------	-------	13
Pennsylvania	3	71	20	3	6	28	131	170	105	26	-------	-------	-------	302
Tennessee	8	35	38	-------	3	-------	84	8	254	368	-------	8	-------	638
Utah	-------	4	-------	1	6	-------	11	-------	-------	-------	3	18	-------	21
Virginia	414	1,182	763	602	385	60	3,406	684	2,117	1,817	1,047	1,427	418	7,509
Washington	-------	-------	-------	-------	-------	1	1	-------	-------	-------	-------	-------	8	8
West Virginia	193	756	287	68	29	-------	1,333	832	2,361	1,200	237	246	-------	4,876
Total [1]	785	2,559	1,527	918	440	96	6,325	2,274	6,843	5,810	4,386	3,294	426	23,082
1968														
Illinois	1	-------	-------	-------	-------	-------	1	1	-------	-------	-------	-------	-------	1
Kentucky	118	532	247	230	37	-------	1,164	340	2,574	989	1,143	199	-------	5,245
Maryland	-------	13	-------	-------	-------	-------	13	-------	48	-------	-------	-------	-------	48
Ohio	-------	6	-------	-------	-------	-------	6	-------	4	-------	-------	-------	-------	4
Pennsylvania	-------	52	28	-------	-------	28	108	-------	70	13	-------	-------	-------	84
Tennessee	8	37	27	-------	3	-------	75	7	104	116	-------	40	-------	267
Utah	-------	5	-------	1	5	-------	11	-------	2	-------	2	16	-------	21
Virginia	329	1,984	327	109	7	-------	2,756	489	4,344	2,058	822	6	-------	7,715
Washington	-------	-------	-------	1	-------	-------	1	-------	-------	-------	9	-------	-------	9
West Virginia	124	635	248	83	28	10	1,128	236	1,325	1,036	556	159	53	3,366
Total [1]	580	3,264	877	424	80	38	5,268	1,078	8,472	4,207	2,582	421	53	16,758

[1] Data may not add to totals shown because of independent rounding.

Table 15.—Number and production of underground bituminous coal and lignite mines using gathering and haulage conveyors, and number and length of units in use, in the United States, by States[1]

State	Number of mines		Production (thousand short tons)		Number of units in use		Average length (feet)		Total length (miles)	
	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968
Alabama	7	6	4,087	4,200	72	79	2,077	2,115	28.3	31.6
Colorado	8	7	2,139	1,919	30	28	1,643	2,250	9.3	11.9
Illinois	18	22	26,406	25,125	171	214	2,260	2,138	73.2	86.7
Indiana	2	2	1,317	1,875	11	11	2,759	2,759	5.7	5.7
Kentucky	64	73	31,310	33,589	296	353	1,939	2,068	108.7	138.2
Maryland	4	4	228	210	14	7	1,050	1,057	2.8	1.4
New Mexico	1	1	660	763	4	5	3,675	2,040	2.8	1.9
Ohio	23	23	12,423	13,806	95	103	1,739	1,875	31.3	36.6
Pennsylvania	117	115	31,906	34,283	574	578	1,657	1,752	180.1	191.8
Tennessee	8	9	1,470	1,831	27	41	1,060	2,525	5.4	19.6
Utah	15	14	3,462	3,918	60	56	1,716	1,608	19.5	17.1
Virginia	33	39	14,413	16,219	183	240	2,498	2,315	86.6	105.2
West Virginia	321	312	101,508	102,385	1,244	1,250	1,707	1,725	402.2	408.4
Wyoming	2	1	107	106	7	4	1,071	1,500	1.4	1.1
Total[2]	623	628	231,436	240,229	2,788	2,969	1,813	1,880	957.3	1,057.2

[1] Includes all mines using belt conveyors, 500 feet long or more for transporting coal underground. Excludes main-slope conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1967, by States and counties

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day[1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
Alabama:													
Bibb	2	5	-------	35	49	-------	224	252	-------	8.37	20.33	-------	15.44
Blount	-------	4	-------	-------	59	-------	-------	235	-------	-------	16.92	-------	16.92
Jackson	3	1	-------	11	40	-------	31	302	-------	12.20	51.21	-------	50.18
Jefferson	42	19	-------	2,813	226	-------	220	265	-------	10.31	31.40	-------	12.17
Marion	24	3	-------	242	31	-------	191	171	-------	6.09	35.35	-------	9.13
Shelby	6	1	-------	276	3	-------	229	157	-------	8.86	20.05	-------	8.95
Tuscaloosa	1	9	1	9	178	5	224	177	22	13.36	24.61	16.96	23.91
Walker	13	17	3	648	293	28	224	224	159	14.04	29.11	17.96	18.71
Other counties[2]	-------	3	-------	-------	56	-------	-------	214	-------	-------	16.33	-------	16.33
Total	91	62	4	4,034	935	33	219	227	137	10.59	28.47	17.93	14.07

Alaska	-------	4	-------	-------	133	-------	-------	278	-------	-------	24.97	-------	24.97
Arizona: Coconino	1	-------	-------	3	-------	-------	140	-------	-------	2.40	-------	-------	2.40
Arkansas:													
Franklin	-------	1	-------	-------	19	-------	-------	195	-------	-------	19.82	-------	19.82
Other counties [2]	3	3	-------	51	33	-------	152	212	-------	5.79	10.14	-------	7.73
Total	3	4	-------	51	52	-------	152	198	-------	5.79	13.98	-------	10.46
Colorado:													
Garfield	2	-------	-------	6	-------	-------	208	-------	-------	2.99	-------	-------	2.99
Gunnison	4	-------	-------	77	-------	-------	326	-------	-------	17.54	-------	-------	17.54
LaPlata	5	-------	-------	18	-------	-------	169	-------	-------	6.87	-------	-------	6.87
Weld	5	-------	-------	211	-------	-------	194	-------	-------	16.41	-------	-------	16.41
Other counties [2]	39	7	1	926	112	5	214	250	75	12.30	66.39	10.11	19.03
Total	55	7	1	1,238	112	5	217	250	75	13.30	66.39	10.11	18.31
Illinois:													
Adams	-------	1	-------	-------	11	-------	-------	112	-------	-------	13.23	-------	13.23
Fulton	-------	7	-------	-------	757	-------	-------	277	-------	-------	32.30	-------	32.30
Greene	-------	1	-------	-------	2	-------	-------	120	-------	-------	8.66	-------	8.66
Jackson	-------	5	-------	-------	70	-------	-------	157	-------	-------	65.24	-------	65.24
Macoupin	1	-------	-------	157	-------	-------	223	-------	-------	11.74	-------	-------	11.74
Peoria	1	3	-------	3	137	-------	55	283	-------	10.86	38.30	-------	38.17
Perry	-------	4	-------	-------	529	-------	-------	324	-------	-------	64.43	-------	64.43
Vermilion	2	2	-------	30	107	-------	215	259	-------	7.98	20.75	-------	18.35
Williamson	8	7	-------	705	278	-------	263	274	-------	19.54	33.03	-------	23.47
Other counties [2]	20	13	-------	3,986	1,216	-------	256	294	-------	23.34	39.28	-------	27.50
Total	32	43	-------	4,881	3,107	-------	256	288	-------	22.38	41.59	-------	30.40
Indiana:													
Clay	-------	5	-------	-------	150	-------	-------	290	-------	-------	27.47	-------	27.47
Greene	-------	5	-------	-------	163	-------	-------	316	-------	-------	41.32	-------	41.32
Parke	-------	1	-------	-------	9	-------	-------	145	-------	-------	7.40	-------	7.40
Spencer	-------	5	-------	-------	32	-------	-------	211	-------	-------	14.07	-------	14.07
Sullivan	2	3	-------	242	259	-------	230	256	-------	19.75	40.82	-------	31.20
Warrick	2	10	-------	21	481	-------	165	299	-------	7.70	57.98	-------	56.78
Other counties [2]	7	8	-------	183	311	-------	213	264	-------	13.18	32.52	-------	26.30
Total	11	37	-------	446	1,405	-------	220	281	-------	16.72	43.39	-------	38.08
Iowa:													
Appanoose	2	-------	-------	35	-------	-------	93	-------	-------	2.12	-------	-------	2.12
Lucas	1	-------	-------	18	-------	-------	293	-------	-------	19.13	-------	-------	19.13
Mahaska	-------	7	-------	-------	81	-------	-------	197	-------	-------	20.61	-------	20.61
Marion	1	4	-------	2	38	-------	92	274	-------	5.90	24.18	-------	23.88
Monroe	1	-------	-------	20	-------	-------	296	-------	-------	31.19	-------	-------	31.19
Van Buren	-------	1	-------	-------	7	-------	-------	137	-------	-------	12.68	-------	12.68
Total	5	12	-------	75	126	-------	196	215	-------	20.09	21.69	-------	21.13
Kansas: Total [2]	-------	5	-------	-------	209	-------	-------	232	-------	-------	23.48	-------	23.48

See footnotes at end of table.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1967, by States and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Under-ground	Strip	Auger	Total
Kentucky:													
Eastern:													
Bell	40	11	10	620	231	60	149	188	114	10.21	31.87	52.15	18.81
Boyd	1	1	-------	6	4	-------	19	287	-------	8.65	10.44	-------	10.28
Breathitt	7	7	4	82	161	61	104	256	143	12.15	37.71	69.32	38.71
Carter	2	-------	-------	19	-------	-------	136	-------	-------	7.71	-------	-------	7.71
Clay	41	2	4	633	11	29	145	135	90	6.52	38.93	32.09	7.72
Clinton	3	-------	-------	23	-------	-------	62	-------	-------	8.45	-------	-------	8.45
Elliott	1	-------	-------	3	-------	-------	57	-------	-------	15.36	-------	-------	15.36
Harlan	92	7	13	2,173	61	83	218	141	160	12.02	36.40	30.97	12.95
Jackson	2	-------	-------	14	-------	-------	100	-------	-------	5.06	-------	-------	5.06
Johnson	38	2	1	262	39	7	140	106	40	6.90	54.08	7.33	11.68
Knott	74	3	11	754	33	57	134	290	120	14.65	25.86	59.51	18.18
Knox	39	-------	3	201	-------	18	110	-------	103	6.07	-------	64.50	10.51
Laurel	2	-------	-------	10	-------	-------	121	-------	-------	10.31	-------	-------	10.31
Lawrence	1	1	-------	9	4	-------	47	4	-------	7.46	62.50	-------	9.57
Lee	1	-------	-------	24	-------	-------	178	-------	-------	4.78	-------	-------	4.78
Leslie	25	-------	2	646	-------	13	210	-------	51	11.54	-------	37.81	11.68
Letcher	185	6	12	2,230	55	86	180	162	102	14.41	45.90	39.38	15.60
McCreary	9	1	-------	225	6	-------	183	160	-------	13.06	19.27	-------	13.20
Martin	9	-------	1	192	-------	8	215	-------	7	16.41	-------	37.48	16.44
Morgan	1	5	-------	9	18	-------	130	110	-------	3.30	9.61	-------	7.21
Perry	73	13	20	1,360	101	166	173	172	161	11.77	51.56	60.42	18.89
Pike	391	3	53	5,396	25	283	174	151	88	17.08	58.85	73.97	18.70
Pulaski	12	1	1	103	8	4	237	200	104	10.69	62.50	62.50	14.63
Wayne	-------	1	-------	-------	5	-------	-------	145	-------	-------	13.83	-------	13.83
Whitley	35	1	2	279	3	7	154	70	13	8.45	28.57	33.50	8.60
Other counties [2]	164	1	3	2,193	11	27	190	51	64	12.41	43.04	69.58	12.70
Total	1,248	66	140	17,466	776	909	178	188	114	13.62	37.73	57.48	16.02
Western:													
Henderson	4	-------	-------	70	-------	-------	258	-------	-------	12.03	-------	-------	12.03
Hopkins	13	12	2	1,384	376	9	229	250	22	23.04	51.12	83.53	29.49
Muhlenberg	6	8	-------	364	1,025	-------	176	324	-------	22.35	55.28	-------	49.93
Ohio	2	9	1	125	403	4	247	297	40	36.26	48.18	49.28	45.74
Other counties [2]	11	9	1	1,157	151	5	243	252	60	21.41	35.63	25.00	23.12
Total	36	38	4	3,100	1,955	18	229	298	37	22.63	51.91	46.55	35.84
Grand total	1,284	104	144	20,566	2,731	927	186	267	113	15.30	49.07	57.40	21.53

Maryland:													
Allegany	8	12	1	58	52	4	173	254	105	7.16	16.70	13.78	12.64
Garrett	11	19	2	109	104	12	218	209	147	12.96	30.16	33.10	21.49
Total	19	31	3	167	156	16	203	225	101	11.27	25.11	27.90	18.51
Missouri:													
Callaway	------	1	------	------	8	------	------	286	------	------	13.50	------	13.50
Dade	------	1	------	------	2	------	------	280	------	------	16.07	------	16.07
Putnam	1	2	------	4	18	------	120	255	------	2.35	18.20	------	16.86
Vernon	------	3	------	------	31	------	------	215	------	------	12.08	------	12.08
Other counties [2]	------	6	------	------	302	------	------	315	------	------	36.74	------	36.74
Total	1	13	------	4	361	------	120	304	------	2.35	33.68	------	33.56
Montana:													
Bituminous:													
Musselshell	6	------	------	31	------	------	148	------	------	7.61	------	------	7.61
Other counties [2]	2	1	------	19	1	------	53	132	------	6.00	8.88	------	5.46
Total	8	1	------	50	1	------	115	132	------	7.13	8.88	------	7.14
Lignite:													
Sheridan	1	------	------	3	------	------	180	------	------	2.18	------	------	2.18
Other counties [2]	------	2	------	------	18	------	------	239	------	------	76.33	------	76.33
Total	1	2	------	3	18	------	180	239	------	2.18	76.33	------	69.18
Total Montana	9	3	------	53	19	------	117	233	------	6.77	74.28	------	34.88
New Mexico: Total [2]	5	3	------	143	145	------	220	256	------	21.23	75.37	------	50.52
North Dakota:													
Lignite:													
Adams	------	1	------	------	5	------	------	192	------	------	16.88	------	16.88
Bowman	------	1	------	------	15	------	------	168	------	------	54.34	------	54.34
Grant	------	3	------	------	5	------	------	83	------	------	34.20	------	34.20
Mercer	------	3	------	------	124	------	------	256	------	------	90.89	------	90.89
Other counties [2]	------	16	------	------	154	------	------	182	------	------	39.71	------	39.71
Total	------	24	------	------	303	------	------	212	------	------	64.76	------	64.76
Ohio:													
Belmont	10	18	7	1,341	431	28	239	273	58	18.89	37.89	79.70	24.21
Columbiana	5	30	16	19	192	17	191	257	259	11.88	19.17	62.17	21.99
Gallia	6	3	2	18	27	7	167	104	120	8.40	36.88	52.80	26.20
Guernsey	------	10	1	------	162	2	------	262	50	------	46.45	90.00	46.57
Harrison	7	19	4	1,557	459	23	252	268	61	12.78	46.51	66.35	20.95
Hocking	------	7	------	------	35	------	------	107	------	------	14.79	------	14.79
Holmes	------	5	1	------	25	2	------	275	15	------	25.77	33.33	25.95
Jefferson	4	33	11	246	473	29	223	264	137	16.89	28.78	49.52	25.68
Mahoning	------	12	------	------	89	------	------	269	------	------	23.63	------	23.63
Tuscarawas	6	29	6	169	362	18	227	287	181	13.61	20.42	63.87	19.61

See footnotes at end of table.

Table 16.—Number of mines, men working daily, days active, and output per man day at bituminous coal and lignite mines in the United States, in 1967, by States and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
Ohio—Continued													
Other counties [2]	29	107	13	612	1,066	96	242	257	167	17.49	34.62	42.00	29.24
Total	67	273	61	3,962	3,321	222	242	263	146	15.81	33.51	50.47	24.69
Oklahoma:													
Craig	-------	3	-------	-------	40	-------	-------	210	-------	-------	9.65	-------	9.65
LeFlore	1	-------	-------	34	-------	-------	37	-------	-------	1.58	-------	-------	1.58
Muskogee	-------	1	-------	-------	2	-------	-------	180	-------	-------	5.00	-------	5.00
Okmulgee	-------	1	-------	-------	2	-------	-------	89	-------	-------	14.31	-------	14.31
Other counties [2]	-------	4	1	-------	151	5	-------	199	10	-------	24.43	44.22	24.50
Total	1	9	1	34	195	5	37	201	10	1.58	20.92	44.22	20.34
Pennsylvania:													
Armstrong	31	45	11	978	311	72	227	189	94	18.88	24.25	42.09	20.52
Butler	8	32	5	148	269	12	247	252	179	16.22	19.83	39.01	18.99
Cambria	57	22	6	2,715	205	23	237	242	79	10.50	18.15	33.74	11.11
Centre	3	12	2	128	98	15	229	268	75	13.42	14.05	22.52	13.89
Clearfield	25	57	9	430	1,074	24	229	283	203	16.04	16.93	38.47	16.97
Clinton	-------	12	-------	-------	119	-------	-------	300	-------	-------	26.13	-------	26.13
Elk	4	9	4	20	53	9	166	277	170	12.87	16.60	22.32	16.40
Fayette	7	24	-------	78	87	-------	238	159	-------	13.00	20.66	-------	16.29
Indiana	45	30	7	1,911	171	16	236	181	145	15.41	19.16	54.07	15.84
Jefferson	18	41	12	207	198	29	233	235	142	14.24	21.06	24.99	17.90
Lawrence	-------	19	-------	-------	184	-------	-------	288	-------	-------	17.43	-------	17.43
Lycoming	-------	5	-------	-------	40	-------	-------	176	-------	-------	16.11	-------	16.11
Mercer	-------	6	-------	-------	94	-------	-------	201	-------	-------	16.13	-------	16.13
Tioga	-------	7	-------	-------	101	-------	-------	295	-------	-------	23.95	-------	23.95
Venango	-------	13	-------	-------	88	-------	-------	242	-------	-------	24.15	-------	24.15
Washington	16	15	1	4,063	142	4	245	162	28	14.35	21.34	20.12	14.51
Other counties [2]	98	168	5	6,558	1,194	20	223	240	50	14.22	23.37	33.00	15.72
Total	312	517	62	17,236	4,428	224	233	246	113	14.09	20.22	36.93	15.50
South Dakota (lignite): Dewey	-------	1	-------	-------	5	-------	-------	108	-------	-------	9.79	-------	9.79
Tennessee:													
Anderson	23	9	2	411	70	7	226	218	244	18.20	37.65	38.23	21.22
Bledsoe	-------	2	-------	-------	15	-------	-------	52	-------	-------	35.12	-------	35.12
Campbell	19	15	4	203	187	11	159	104	118	8.88	28.98	50.83	17.30
Claiborne	6	3	1	126	52	3	231	248	150	12.53	19.36	10.60	14.58
Cumberland	1	2	-------	1	10	-------	240	100	-------	10.00	25.00	-------	23.64

Fentress	7	3	-------	31	10	-------	209	79	-------	5.81	24.98	-------	7.67
Grundy	-------	3	-------	-------	47	-------	-------	238	-------	-------	21.72	-------	21.72
Hamilton	3	1	-------	14	5	-------	221	200	-------	9.20	27.77	-------	13.82
Marion	28	-------	-------	313	-------	-------	196	-------	-------	14.95	-------	-------	14.95
Morgan	11	9	1	62	35	4	203	195	168	8.92	34.94	87.47	20.36
Overton	6	-------	-------	33	-------	-------	127	-------	-------	13.72	-------	-------	13.72
Putnam	1	-------	-------	20	-------	-------	186	-------	-------	13.44	-------	-------	13.44
Rhea	2	-------	-------	8	-------	-------	108	-------	-------	13.87	-------	-------	13.87
Scott	10	3	1	102	37	4	202	162	75	17.15	25.12	11.28	18.88
Sequatchie	9	3	-------	41	23	-------	145	264	-------	7.59	39.54	-------	23.82
Van Buren	-------	5	-------	-------	42	-------	-------	245	-------	-------	31.07	-------	31.07
Total	126	58	9	1,365	533	29	200	172	155	14.48	29.25	44.85	18.51
Utah:													
Carbon	14	-------	-------	877	-------	-------	210	-------	-------	16.14	-------	-------	16.14
Emery	6	-------	-------	338	-------	-------	214	-------	-------	15.37	-------	-------	15.37
Kane	1	-------	-------	2	-------	-------	168	-------	-------	6.30	-------	-------	6.30
Other counties [2]	3	-------	-------	21	-------	-------	238	-------	-------	17.60	-------	-------	17.60
Total	24	-------	-------	1,238	-------	-------	210	-------	-------	16.02	-------	-------	16.02
Virginia:													
Buchanan	520	23	28	6,159	211	147	180	185	129	12.27	27.87	44.34	13.31
Dickenson	75	13	10	2,057	116	37	232	224	196	17.03	45.23	38.25	18.77
Wise	113	23	18	1,731	185	57	213	218	164	16.28	37.35	70.98	19.53
Other counties [2]	76	11	8	1,030	89	51	205	169	196	13.11	28.80	24.40	14.59
Total	784	70	64	10,977	601	292	197	201	155	14.08	34.79	44.85	15.75
Washington:													
Lewis	-------	1	-------	-------	1	-------	-------	175	-------	-------	15.43	-------	15.43
Other counties [2]	3	-------	-------	39	-------	-------	168	-------	-------	8.56	-------	-------	8.56
Total	3	1	-------	39	1	-------	168	175	-------	8.56	15.43	-------	8.76
West Virginia:													
Barbour	36	19	2	759	291	6	209	146	56	13.02	31.75	91.84	17.09
Boone	49	11	17	1,955	135	228	212	211	161	16.41	38.93	42.11	19.71
Braxton	1	-------	-------	3	-------	-------	87	-------	-------	4.28	-------	-------	4.28
Brooke	5	4	1	174	36	4	257	142	127	15.24	15.27	59.29	15.69
Fayette	77	17	10	1,934	156	53	197	184	229	11.34	28.55	39.01	13.31
Gilmer	8	1	-------	144	12	-------	170	105	-------	12.90	18.10	-------	13.15
Greenbrier	36	1	-------	256	4	-------	166	122	-------	14.52	37.79	-------	14.80
Harrison	22	21	5	1,298	199	19	230	139	109	20.33	31.34	81.69	21.64
Kanawha	66	6	11	2,700	109	111	209	209	145	17.81	33,21	46.26	19.15
Logan	62	4	12	4,855	86	126	235	136	165	14.05	18.28	43.52	14.62
Marion	11	5	-------	3,128	20	-------	257	126	-------	18.64	22.24	-------	18.65
Marshall	4	-------	-------	719	-------	-------	247	-------	-------	18.27	-------	-------	18.27
Mason	5	1	-------	118	29	-------	225	212	-------	10.29	11.85	-------	10.55
McDowell	201	18	8	5,919	205	51	213	195	115	13.09	32.65	15.10	13.70

See footnotes at end of table.

Table 16.—Number of mines, men working daily, days active, and output per man per day at bituminous coal and lignite mines in the United States, in 1967, by States and counties—Continued

State and county	Number of mines			Average number of men working daily			Average number of days worked			Average tons per man per day [1]			
	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Underground	Strip	Auger	Total
West Virginia—Continued													
Mercer	16	7	2	485	65	23	222	217	135	11.60	29.50	8.51	13.56
Mingo	51	1	7	1,452	20	73	193	88	131	16.75	18.86	56.51	18.07
Monongalia	31	9	2	1,806	44	5	256	144	239	22.18	31.15	15.35	22.28
Raleigh	69	16	6	2,846	100	58	228	218	197	11.47	35.12	35.26	12.62
Webster	20	5	2	323	27	38	73	109	29	9.68	69.33	31.93	16.95
Wyoming	100	6	12	4,989	59	66	231	164	149	13.22	36.72	30.58	13.56
Other counties [2]	200	65	12	4,990	715	38	208	203	53	14.55	24.03	57.50	15.79
Total	1,070	217	109	40,853	2,312	899	222	181	149	15.04	28.99	40.51	16.01
Wyoming:													
Campbell	-------	1	-------	-------	29	-------	-------	262	-------	-------	66.56	-------	66.56
Other counties [2]	5	8	-------	67	220	-------	167	236	-------	10.45	57.04	-------	48.17
Total	5	9	-------	67	249	-------	167	241	-------	10.45	57.91	-------	50.44
Total United States	3,908	1,507	458	107,432	21,439	2,652	216	248	133	15.07	35.17	46.48	19.17

[1] In certain counties the average tons per man per day is large because of auger mining, strip mining, or mechanical loading underground.

[2] Other counties. Alabama, strip: Cullman, Etowah, Winston. Arkansas, underground: Johnson; strip: Johnson, Sebastian. Colorado, underground: Delta, Tremont, Huerfano, Las Animas, Mesa, Moffat, Pitkin, Rio Blanco, Routt; strip: Fremont, Moffat, Montrose, Routt; Auger: Fremont, Illinois, underground: Christian, Douglas, Franklin, Gallatin, Jefferson, Logan, Mercer, Montgomery, Randolph, St. Clair, Saline, Washington; strip: Gallatin, Grundy, Knox, Randolph, St. Clair, Saline, Stark, Will. Indiana, underground: Gibson, Knox, Pike, Vermillion, Vigo; strip: Daviess, Fountain, Gibson, Owen, Pike, Vigo. Kansas, strip: Cherokee, Crawford. Kentucky, eastern, underground: Floyd, Magoffin; strip: Floyd; auger: Floyd, Magoffin. Kentucky, western, underground: Butler, Union, Webster; strip: Butler, Daviess, Webster; auger: Butler. Missouri, strip: Boone, Clark, Henry, Macon. Montana, bituminous, underground: Blaine, Carbon; strip: Big Horn. Montana, lignite, strip: Powder River, Richland. New Mexico, underground: Colfax, Sandoval, San Juan; strip: McKinley, San Juan. North Dakota, strip: Burke, Burleigh, McLean, Morton, Oliver, Stark, Ward, Williams. Ohio, underground: Athens, Carroll, Coshocton, Jackson, Meigs, Monroe, Muskingum, Perry, Vinton; strip: Carroll, Coshocton, Jackson, Lawrence, Meigs, Morgan, Muskingum, Noble, Perry, Stark, Vinton, Washington, Wayne; auger: Carroll, Coshocton, Jackson, Muskingum, Noble, Perry, Stark. Oklahoma, strip: Haskell, Rogers; auger: Haskell. Pennsylvania, underground: Allegheny, Beaver, Bedford, Blair, Clarion, Greene, Huntingdon, Somerset, Westmoreland; strip: Allegheny, Beaver, Bedford, Blair, Clarion, Greene, Huntingdon, Somerset, Westmoreland; auger: Allegheny, Huntingdon, Somerset, Westmoreland. Utah, underground: Iron, Sevier, Summit. Virginia, underground: Lee, Montgomery, Russell, Scott, Tazewell; strip; Lee, Russell, Tazewell; auger: Lee, Russell, Tazewell. Washington, underground: King, Thurston. West Virginia, underground: Clay, Grant, Lewis, Mineral, Nicholas, Ohio, Pocahontas, Preston, Randolph, Taylor, Upshur, Wayne; strip: Clay, Grant, Hancock, Lewis, Mineral, Nicholas, Preston, Randolph, Taylor, Tucker, Upshur; auger: Lewis, Mineral, Nicholas, Pocahontas, Preston, Randolph, Upshur. Wyoming, underground: Hot Springs, Sweetwater; strip: Carbon, Converse, Lincoln, Sheridan.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1967, by States and counties

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Alabama:											
Bibb	2	66	5	232	---------	---------	150	148	---------	298	$5.51
Blount	---------	---------	4	233	---------	---------	148	85	---------	233	7.21
Jackson	3	4	1	618	---------	---------	618	4	---------	622	4.26
Jefferson	42	6,381	19	1,882	---------	---------	7,476	787	---------	8,263	7.84
Marion	24	282	3	190	---------	---------	9	463	---------	472	4.22
Shelby	6	561	1	8	---------	---------	533	37	---------	570	9.30
Tuscaloosa	1	27	9	774	1	2	599	204	---------	803	4.27
Walker	13	2,039	17	1,910	3	79	2,760	555	713	4,028	7.00
Other counties [4]	---------	---------	3	196	---------	---------	27	170	---------	196	5.20
Total [5]	91	9,362	62	6,043	4	81	12,319	2,453	713	15,486	7.15
Alaska	---------	---------	4	925	---------	---------	913	8	4	925	7.89
Arizona: Coconino	1	1	---------	---------	---------	---------	---------	1	---------	1	5.35
Arkansas:											
Franklin	---------	---------	1	73	---------	---------	73	---------	---------	73	7.16
Other counties [4]	3	45	3	71	---------	---------	116	---------	---------	116	7.81
Total [5]	3	45	4	144	---------	---------	189	---------	---------	189	7.56
Colorado:											
Garfield	2	4	---------	---------	---------	---------	---------	4	---------	4	9.21
Gunnison	4	441	---------	---------	---------	---------	390	50	1	441	5.83
LaPlata	5	21	---------	---------	---------	---------	---------	20	1	21	4.98
Weld	5	672	---------	---------	---------	---------	438	230	5	672	4.16
Other counties [4]	39	2,436	7	1,862	1	4	3,159	1,039	103	4,301	4.75
Total [5]	55	3,574	7	1,862	1	4	3,986	1,344	110	5,439	4.77
Illinois:											
Adams	---------	---------	1	16	---------	---------	---------	16	---------	16	6.68
Fulton	---------	---------	7	6,771	---------	---------	6,218	550	4	6,771	4,05
Greene	---------	---------	1	2	---------	---------	---------	2	---------	2	4.65
Jackson	---------	---------	5	715	---------	---------	715	---------	---------	715	3.03
Macoupin	1	412	---------	---------	---------	---------	289	120	3	412	4.09
Peoria	1	2	3	1,488	---------	---------	1,203	287	---------	1,490	4.82
Perry	---------	---------	4	11,041	---------	---------	10,824	213	3	11,041	3.42
Vermilion	2	51	2	574	---------	---------	457	165	3	625	4.95

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1967, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Illinois—Continued											
Williamson	8	3,625	7	2,517	--------	--------	5,707	430	4	6,142	4.03
Other counties [4]	20	23,856	13	14,063	--------	--------	31,361	3,457	3,099	37,917	3.93
Total [5]	32	27,948	43	37,185	--------	--------	56,776	5,241	3,117	65,133	3.88
Indiana:											
Clay	--------	--------	5	1,195	--------	--------	614	579	2	1,195	4.11
Greene	--------	--------	5	2,123	--------	--------	1,941	183	--------	2,123	3.93
Parke	--------	--------	1	10	--------	--------	--------	10	--------	10	5.97
Spencer	--------	--------	5	96	--------	--------	20	76	--------	96	4.05
Sullivan	2	1,100	3	2,708	--------	--------	2,530	290	988	3,808	3.98
Warrick	2	27	10	8,332	--------	--------	6,277	644	1,437	8,358	3.74
Other counties [4]	7	514	8	2,667	--------	--------	2,547	634	--------	3,182	4.18
Total [5]	11	1,641	37	17,131	--------	--------	13,930	2,414	2,429	18,772	3.91
Iowa:											
Appanoose	2	7	--------	--------	--------	--------	--------	7	--------	7	7.02
Lucas	1	101	--------	--------	--------	--------	81	20	--------	101	3.58
Mahaska	--------	--------	7	327	--------	--------	271	56	--------	327	3.67
Marion	1	1	4	249	--------	--------	241	9	--------	250	3.61
Monroe	1	185	--------	--------	--------	--------	29	156	--------	185	3.51
Van Buren	--------	--------	1	12	--------	--------	--------	12	--------	12	4.85
Total [5]	5	295	12	588	--------	--------	622	261	--------	883	3.66
Kansas: Total [4]	--------	--------	5	1,136	--------	--------	1,016	120	--------	1,136	4.66
Kentucky:											
Eastern:											
Bell	40	943	11	1,383	10	354	2,543	138	--------	2,681	3.61
Boyd	1	1	1	12	--------	--------	--------	11	2	13	5.28
Breathitt	7	103	7	1,559	4	606	2,180	87	--------	2,267	2.97
Carter	2	20	--------	--------	--------	--------	--------	20	--------	20	5.50
Clay	41	598	2	58	4	84	281	459	--------	740	3.94
Clinton	3	12	--------	--------	--------	--------	--------	12	--------	12	4.00
Elliott	1	3	--------	--------	--------	--------	--------	3	--------	3	4.43
Harlan	92	5,694	7	313	13	411	6,320	92	7	6,418	5.10
Jackson	2	7	--------	--------	--------	--------	--------	7	--------	7	5.00

Johnson	38	253	2	224	1	2	480	---------	---------	480	2.53
Knott	74	1,481	3	248	11	407	2,136	---------	---------	2,136	3.34
Knox	39	184	---------	---------	3	117	160	91	---------	251	3.22
Laurel	2	13	---------	---------	---------	---------	3	10	---------	13	4.40
Lawrence	1	3	1	1	---------	---------	---------	4	---------	4	3.98
Lee	1	20	---------	---------	---------	---------	5	14	1	20	5.06
Leslie	25	1,561	---------	---------	2	25	1,570	16	---------	1,587	4.28
Letcher	185	5,785	6	409	12	347	6,487	27	26	6,541	5.02
McCreary	9	537	1	18	---------	---------	530	25	---------	555	3.88
Martin	9	677	---------	---------	1	2	672	7	---------	679	2.80
Morgan	1	4	5	19	---------	---------	11	13	---------	23	5.31
Perry	73	2,770	13	898	20	1,610	5,267	3	8	5,278	4.15
Pike	391	16,037	3	218	53	1,842	16,784	1,298	14	18,097	4.33
Pulaski	12	262	1	100	1	26	185	203	---------	388	3.84
Wayne	---------	---------	1	11	---------	---------	11	---------	---------	11	2.71
Whitley	35	363	1	6	2	3	296	76	---------	372	3.02
Other counties [4]	164	5,163	1	25	3	121	5,158	148	2	5,308	5.62
Total [5]	1,248	42,442	66	5,503	140	5,959	51,078	2,765	61	53,904	4.42
Western:											
Henderson	4	216	---------	---------	---------	---------	---------	216	---------	216	3.15
Hopkins	13	7,301	12	4,809	2	17	11,875	252	---------	12,127	3.59
Muhlenberg	6	1,427	8	18,352	---------	---------	14,618	5,162	---------	19,779	3.29
Ohio	2	1,117	9	5,768	1	7	6,542	350	---------	6,892	3.31
Other counties [4]	11	6,016	9	1,354	1	8	6,677	699	---------	7,376	3.59
Total [5]	36	16,077	38	30,282	4	31	39,711	6,678	---------	46,390	3.42
Grand total [5]	1,284	58,519	104	35,785	144	5,990	90,789	9,443	61	100,294	3.96
Maryland:											
Allegany	8	72	12	221	1	6	114	186	---------	300	4.52
Garrett	11	308	19	658	2	39	633	372	---------	1,005	3.17
Total [5]	19	381	31	880	3	45	747	558	---------	1,305	3.48
Missouri:											
Callaway	---------	---------	1	31	---------	---------	---------	31	---------	31	5.64
Dade	---------	---------	1	9	---------	---------	---------	9	---------	9	4.85
Putnam	1	1	2	84	---------	---------	41	44	---------	85	3.45
Vernon	---------	---------	3	81	---------	---------	76	5	---------	81	4.11
Other counties [4]	---------	---------	6	3,490	---------	---------	1,839	294	1,357	3,490	4.22
Total [5]	1	1	13	3,694	---------	---------	1,956	382	1,357	3,696	4.21
Montana:											
Bituminous:											
Musselshell	6	35	---------	---------	---------	---------	2	33	---------	35	8.33
Other counties [4]	2	6	1	1	---------	---------	3	3	---------	7	7.33
Total [5]	8	41	1	1	---------	---------	5	36	---------	42	8.08

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1967, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Montana—Continued											
Lignite:											
Sheridan	1	1	---	---	---	---	---	1	---	1	4.50
Other counties [4]	---	---	2	328	---	---	325	2	---	328	2.84
Total [5]	1	1	2	328	---	---	325	3	---	329	1.97
Total Montana [5]	9	42	3	329	---	---	330	41	---	371	2.68
New Mexico: Total [4]	5	668	3	2,795	---	---	974	2,451	38	3,463	3.65
North Dakota (lignite):											
Adams	---	---	1	16	---	---	10	6	---	16	3.27
Bowman	---	---	1	137	---	---	81	56	---	137	1.91
Grant	---	---	3	14	---	---	---	14	---	14	3.31
Mercer	---	---	3	2,876	---	---	1,860	26	990	2,876	1.82
Other counties [4]	---	---	16	1,113	---	---	673	285	155	1,112	2.14
Total [5]	---	---	24	4,156	---	---	2,623	387	1,146	4,156	1.92
Ohio:											
Belmont	10	6,052	18	4,463	7	132	10,291	298	58	10,647	4.06
Columbiana	5	43	30	948	16	274	166	1,098	---	1,264	3.34
Gallia	6	25	3	103	2	44	157	16	---	173	2.75
Guernsey	---	---	10	1,975	1	11	935	1,042	8	1,986	2.63
Harrison	7	5,016	19	5,716	4	93	10,130	632	64	10,826	4.14
Hocking	---	---	7	56	---	---	---	56	---	56	3.34
Holmes	---	---	5	175	1	1	61	116	---	177	3.04
Jefferson	4	925	33	3,597	11	195	2,475	2,234	8	4,718	3.73
Mahoning	---	---	12	563	---	---	---	507	57	563	3.82
Tuscarawas	6	521	29	2,123	6	211	551	2,296	8	2,855	3.55
Other counties [4]	29	2,589	107	9,486	13	672	4,691	5,424	2,633	12,748	3.79
Total [5]	67	15,172	273	29,209	61	1,633	29,457	13,720	2,837	46,014	3.84
Oklahoma:											
Craig	---	---	3	81	---	---	74	7	---	81	3.83
LeFlore	1	2	---	---	---	---	2	---	---	2	8.00
Muskogee	---	---	1	2	---	---	---	2	---	2	4.00
Okmulgee	---	---	1	3	---	---	---	3	---	3	5.71

Other counties [4]	---------	---------	4	733	---------	---------	732	3	---------	735	5.93
Total [5]	1	2	9	819	---------	---------	808	15	---------	823	5.72
Pennsylvania:											
Armstrong	31	4,190	45	1,426	11	283	2,773	2,076	1,050	5,899	4.24
Butler	8	594	32	1,343	5	86	1,171	852	---------	2,023	3.82
Cambria	57	6,757	22	899	6	61	6,866	841	11	7,718	5.98
Centre	3	392	12	369	2	25	536	250	---------	786	3.93
Clearfield	25	1,581	57	5,144	9	184	4,988	1,922	---------	6,910	3.73
Clinton	---------	---------	12	929	---------	---------	739	190	---------	929	3.77
Elk	4	43	9	244	4	33	174	146	---------	320	3.90
Fayette	7	240	24	287	---------	---------	297	183	47	527	5.42
Indiana	45	6,951	30	592	7	126	6,694	578	397	7,669	4.50
Jefferson	18	688	41	979	12	104	1,385	384	2	1,771	4.01
Lawrence	---------	---------	19	925	---------	---------	47	878	---------	925	3.83
Lycoming	---------	---------	5	113	---------	---------	25	88	---------	113	3.26
Mercer	---------	---------	6	305	---------	---------	151	154	---------	305	3.73
Tioga	---------	---------	7	715	---------	---------	1	714	---------	715	4.28
Venango	---------	---------	13	517	---------	---------	185	332	---------	517	3.26
Washington	16	14,284	15	491	1	2	13,137	1,630	9	14,776	6.55
Other counties [4]	98	20,771	168	6,706	5	33	22,853	3,883	774	27,510	5.68
Total [5]	312	56,490	517	21,984	62	938	62,021	15,101	2,290	79,412	5.28
South Dakota (lignite): Dewey	---------	---------	1	5	---------	---------	---------	5	---------	5	5.00
Tennessee:											
Anderson	23	1,692	9	574	2	67	1,185	1,148	---------	2,333	4.09
Bledsoe	---------	---------	2	27	---------	---------	27	---------	---------	27	3.90
Campbell	19	286	15	564	4	68	718	200	---------	917	3.62
Claiborne	6	364	3	249	1	5	616	2	---------	618	3.24
Cumberland	1	1	2	25	---------	---------	---------	26	---------	26	3.99
Fentress	7	38	3	19	---------	---------	29	27	---------	56	2.81
Grundy	---------	---------	3	245	---------	---------	238	7	---------	245	4.00
Hamilton	3	28	1	28	---------	---------	9	45	---------	56	4.22
Marion	28	918	---------	---------	---------	---------	842	76	---------	918	5.04
Morgan	11	112	9	236	1	59	14	393	---------	407	3.32
Overton	6	57	---------	---------	---------	---------	53	4	---------	57	3.90
Putnam	1	50	---------	---------	---------	---------	50	---------	---------	50	4.00
Rhea	2	12	---------	---------	---------	---------	---------	12	---------	12	4.41
Scott	10	352	3	151	1	3	482	24	---------	506	3.48
Sequatchie	9	45	3	242	---------	---------	261	26	---------	287	3.74
Van Buren	---------	---------	5	318	---------	---------	165	152	---------	318	3.95
Total [5]	126	3,954	58	2,677	9	202	4,688	2,144	---------	6,832	3.95
Utah:											
Carbon	14	2,971	---------	---------	---------	---------	2,810	148	14	2,971	6.15
Emery	6	1,113	---------	---------	---------	---------	914	186	13	1,113	4.95
Kane	1	2	---------	---------	---------	---------	---------	2	---------	2	2.75
Other counties [4]	3	88	---------	---------	---------	---------	---------	88	---------	88	5.48
Total [5]	24	4,175	---------	---------	---------	---------	3,723	425	27	4,175	5.82

See footnotes at end of table.

Table 17.—Production, shipments, and value at bituminous coal and lignite mines, in the United States, in 1967, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Virginia:											
Buchanan	520	13,602	23	1,088	28	838	14,387	1,141	---------	15,529	4.54
Dickenson	75	8,127	13	1,172	10	280	8,948	631	---------	9,579	4.85
Wise	113	6,003	23	1,504	18	663	7,523	430	218	8,171	4.51
Other counties [4]	76	2,767	11	432	8	244	2,843	600	---------	3,443	5.03
Total [5]	784	30,500	70	4,196	64	2,025	33,701	2,802	218	36,721	4.66
Washington:											
Lewis	---------	---------	1	3	---------	---------	---------	3	---------	3	7.44
Other counties [4]	3	56	---------	---------	---------	---------	18	38	---------	56	8.86
Total [5]	3	56	1	3	---------	---------	18	41	---------	59	8.78
West Virginia:											
Barbour	36	2,066	19	1,348	2	29	3,435	7	---------	3,442	4.51
Boone	49	6,802	11	1,105	17	1,548	9,389	51	15	9,456	4.78
Braxton	1	1	---------	---------	---------	---------	1	---------	---------	1	3.50
Brooke	5	682	4	77	1	30	25	117	648	789	3.58
Fayette	77	4,321	17	819	10	474	5,525	83	6	5,614	4.52
Gilmer	8	316	1	22	---------	---------	338	---------	---------	338	4.54
Greenbrier	36	616	1	18	---------	---------	580	55	---------	635	4.72
Harrison	22	6,070	21	868	5	169	7,087	19	---------	7,106	4.46
Kanawha	66	10,050	6	754	11	747	11,450	91	9	11,551	4.75
Logan	62	16,029	4	214	12	907	17,137	5	7	17,150	5.04
Marion	11	14,985	5	55	---------	---------	15,009	27	4	15,040	5.12
Marshall	4	3,244	---------	---------	---------	---------	1,345	125	1,774	3,244	4.51
Mason	5	274	1	73	---------	---------	186	112	49	346	4.49
McDowell	201	16,502	18	1,307	8	88	17,583	206	108	17,897	6.66
Mercer	16	1,248	7	418	2	26	1,677	12	3	1,693	6.48
Mingo	51	4,693	1	34	7	543	5,109	129	32	5,270	5.43
Monongalia	31	10,254	9	196	2	20	10,272	197	---------	10,470	4.63
Raleigh	69	7,444	16	762	6	404	8,436	148	28	8,611	6.04
Webster	20	228	5	205	2	35	465	3	1	468	4.46
Wyoming	100	15,234	6	357	12	303	15,756	111	28	15,894	5.88
Other counties [4]	200	15,132	65	3,484	12	115	17,634	1,093	5	18,731	4.61
Total [5]	1,070	136,193	217	12,117	109	5,440	148,439	2,593	2,717	153,749	5.21

Wyoming:											
Campbell	---------	---------	1	505	---------	---------	408	16	81	505	1.40
Other counties [4]	5	117	8	2,966	---------	---------	1,063	38	1,982	3,083	3.62
Total [5]	5	117	9	3,471	---------	---------	1,471	54	2,063	3,588	3.31
Total United States [5]	3,908	349,133	1,507	187,134	458	16,360	471,497	62,003	19,127	552,626	4.62

---

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.

[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

[3] Value received or charged for coal f.o.b. mine. Includes a value for coal not sold but used by producers, such as mine fuel and coal coked, as estimated by producers at average prices that might have been received if such coal had been sold commercially.

[4] Other counties. Alabama, strip: Cullman, Etowah, Winston. Arkansas, underground: Johnson; strip: Johnson, Sebastian. Colorado, underground: Delta, Fremont, Huerfano, Las Animas, Mesa, Moffat, Pitkin, Rio Blanco, Routt; strip: Fremont, Moffat, Montrose, Routt; auger: Fremont. Illinois, underground: Christian, Douglas, Franklin, Gallatin, Jefferson, Logan, Mercer, Montgomery, Randolph, St. Clair, Saline, Washington; strip: Gallatin, Grundy, Knox, Randolph, St. Clair, Saline, Stark, Will. Indiana, underground: Gibson, Knox, Pike, Vermillion, Vigo; strip: Daviess, Fountain, Gibson, Owen, Pike, Vigo. Kansas, strip: Cherokee, Crawford. Kentucky, eastern, underground: Floyd, Magoffin; strip: Floyd; auger: Floyd, Magoffin. Kentucky, western, underground: Butler, Union, Webster; strip: Butler, Daviess, Webster; auger: Butler. Missouri, strip: Boone, Clark, Henry, Macon. Montana, bituminous, underground: Blaine, Carbon; strip: Big Horn. Montana, lignite, strip: Powder River, Richmond. New Mexico, underground: Colfax, Sandoval, San Juan; strip: McKinley, San Juan. North Dakota, strip: Burke, Burleigh, McLean, Morton, Oliver, Stark, Ward, Williams. Ohio, underground: Athens, Carroll, Coshocton, Jackson, Meigs, Monroe, Muskingum, Perry, Vinton; strip: Carroll, Coshocton, Jackson, Lawrence, Meigs, Morgan, Muskingum, Noble, Perry, Stark, Vinton, Washington, Wayne; auger: Carroll, Coshocton, Jackson, Muskingum, Noble, Perry, Stark. Oklahoma, strip: Haskell, Rogers; auger: Haskell. Pennsylvania, underground: Allegheny, Beaver, Bedford, Blair, Clarion, Greene, Huntingdon, Somerset, Westmoreland; strip: Allegheny, Beaver, Bedford, Blair, Clarion, Greene, Huntingdon, Somerset, Westmoreland; auger: Allegheny, Huntingdon, Somerset, Westmoreland. Utah, underground: Iron, Sevier, Summit. Virginia, underground: Lee, Montgomery, Russell, Scott, Tazewell; strip: Lee, Russell, Tazewell; auger: Lee, Russell, Tazewell. Washington, underground: King, Thurston. West Virginia, underground: Clay, Grant, Lewis, Mineral, Nicholas, Ohio, Pocahontas, Preston, Randolph, Taylor, Upshur, Wayne; strip: Clay, Grant, Hancock, Lewis, Mineral, Nicholas, Preston, Randolph, Taylor, Tucker, Upshur; auger: Lewis, Mineral, Nicholas, Pocahontas, Preston, Randolph, Upshur. Wyoming, underground: Hot Springs Sweetwater; strip: Carbon, Converse, Lincoln, Sheridan.

[5] Data may not add to totals shown because of independent rounding.

Table 18.—Production, shipments, and value at bituminous coal and lignite mines in the United States, in 1968, by States and counties

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Alabama:											
Jefferson	35	6,129	16	2,231	---	---	7,722	637	1	8,359	$7.69
Walker	9	2,189	16	2,069	2	63	3,073	520	728	4,321	7.14
Other counties [4]	36	934	28	2,825	---	---	2,502	1,260	---	3,758	5.51
Total [5]	80	9,252	60	7,125	2	63	13,295	2,416	729	16,440	7.04
Alaska	---	---	3	750	---	---	745	4	1	750	6.00
Arkansas:											
Franklin	---	---	1	66	---	---	66	---	---	66	7.33
Johnson	2	59	3	81	---	---	140	---	---	140	7.54
Sebastian	---	---	2	5	---	---	2	3	---	5	7.33
Total [5]	2	59	6	152	---	---	208	3	---	211	7.47
Colorado:											
Fremont	13	232	---	---	---	---	2	230	---	232	3.93
Garfield	1	2	---	---	---	---	---	2	---	2	9.50
Gunnison	5	513	---	---	---	---	460	51	2	513	5.60
Huerfano	2	27	---	---	---	---	---	27	---	27	7.70
La Plata	4	23	---	---	---	---	---	23	---	23	4.47
Weld	4	654	---	---	---	---	445	207	2	654	4.25
Other counties [4]	20	2,313	5	1,795	---	---	3,269	759	81	4,108	4.84
Total [5]	49	3,763	5	1,795	---	---	4,176	1,298	85	5,558	4.82
Illinois:											
Adams	---	---	1	13	---	---	---	13	---	13	7.40
Fulton	---	---	6	6,786	---	---	6,299	484	3	6,786	4.17
Jackson	---	---	4	268	---	---	268	---	---	268	2.82
Perry	---	---	4	10,411	---	---	10,189	218	5	10,411	3.41
Vermilion	2	50	1	786	1	10	440	402	3	845	4.98
Williamson	8	2,642	4	2,216	---	---	4,438	415	5	4,857	4.20
Other counties [4]	23	23,701	16	15,560	---	---	32,002	4,146	3,114	39,260	4.11
Total [5]	33	26,392	36	36,039	1	10	53,635	5,677	3,129	62,441	4.01
Indiana:											
Clay	---	---	5	1,063	---	---	411	650	2	1,063	4.20
Parke	---	---	1	12	---	---	---	12	---	12	5.50
Warrick	2	30	9	7,489	---	---	5,481	603	1,435	7,519	3.67

Other counties [4]	7	2,137	20	7,753	---------	---------	7,767	1,086	1,038	9,891	4.00
Total [5]	9	2,168	35	16,318	---------	---------	13,659	2,352	2,475	18,486	3.88
Iowa:											
Mahaska	---------	---------	7	301	---------	---------	200	100	---------	301	3.64
Marion	---------	---------	4	269	---------	---------	269	---------	---------	269	3.73
Van Buren	---------	---------	1	14	---------	---------	---------	14	---------	14	5.09
Other counties [4]	3	293	---------	---------	---------	---------	144	150	---------	293	3.83
Total [5]	3	293	12	584	---------	---------	612	264	---------	876	3.75
Kansas: Total [4]	---------	---------	4	1,268	---------	---------	1,245	23	---------	1,268	5.15
Kentucky:											
Eastern:											
Bell	31	966	17	1,473	17	805	3,081	162	---------	3,244	3.19
Clinton	4	25	---------	---------	---------	---------	---------	25	---------	25	4.00
Elliott	---------	---------	3	10	---------	---------	---------	10	---------	10	4.60
Floyd	154	4,248	3	162	3	198	4,039	569	---------	4,609	5.64
Harlan	87	6,090	11	362	16	453	6,682	202	21	6,905	5.28
Johnson	21	166	2	523	---------	---------	644	45	---------	688	5.50
Knott	63	1,704	3	220	15	373	2,290	6	---------	2,297	3.59
Knox	43	137	1	7	1	10	91	62	---------	153	3.75
Laurel	1	10	---------	---------	---------	---------	10	---------	---------	10	3.84
Leslie	30	1,665	1	38	1	38	1,714	27	---------	1,740	4.60
Letcher	152	5,070	8	606	11	196	5,827	23	21	5,871	4.84
Perry	54	2,353	11	696	24	1,266	4,297	10	9	4,316	4.16
Pike	362	17,675	4	67	44	1,877	19,025	593	2	19,619	4.00
Whitley	31	399	2	11	---------	---------	286	123	---------	409	3.41
Other counties [4]	50	2,320	16	1,627	14	796	3,992	744	7	4,743	3.36
Total [5]	1,083	42,827	82	5,801	146	6,013	51,979	2,602	60	54,641	4.31
Western:											
Henderson	4	195	---------	---------	---------	---------	---------	189	6	195	3.57
Hopkins	14	6,884	12	5,044	3	159	11,870	217	---------	12,087	3.35
Muhlenberg	7	3,466	11	17,177	---------	---------	15,733	4,909	---------	20,643	3.37
Other counties [4]	13	7,322	18	6,211	2	57	12,556	1,033	2	13,589	3.57
Total [5]	38	17,866	41	28,432	5	216	40,159	6,347	8	46,515	3.42
Grand total [5]	1,121	60,694	123	34,233	151	6,229	92,139	8,950	68	101,156	3.91
Maryland: Total [4]	21	354	33	994	7	99	808	640	---------	1,447	3.67
Missouri:											
Callaway	---------	---------	1	27	---------	---------	---------	27	---------	27	5.56
Dade	---------	---------	1	4	---------	---------	---------	4	---------	4	4.42
Putnam	---------	---------	2	55	---------	---------	17	38	---------	55	3.45
Vernon	---------	---------	3	63	---------	---------	56	7	---------	63	3.83
Other counties [4]	---------	---------	5	3,057	---------	---------	1,555	270	1,232	3,057	4.21
Total [5]	---------	---------	12	3,205	---------	---------	1,628	346	1,232	3,205	4.20

Table 18.—Production, shipments, and value at bituminous coal and lignite mines in the United States, in 1968, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Montana:											
Bituminous: Total [4]	7	36	2	153	--------	--------	155	34	--------	189	3.12
Lignite: Total [4]	--------	--------	2	330	--------	--------	329	1	--------	330	1.89
Total Montana [5]	7	36	4	483	--------	--------	484	35	--------	519	2.34
New Mexico: Total [4]	3	768	3	2,662	--------	--------	1,151	2,278	--------	3,429	3.94
North Dakota (lignite):											
Adams	--------	--------	1	11	--------	--------	6	5	--------	11	3.32
Bowman	--------	--------	1	131	--------	--------	131	--------	--------	131	1.88
Grant	--------	--------	3	12	--------	--------	--------	12	--------	12	3.41
McLean	--------	--------	2	29	--------	--------	--------	29	--------	29	3.64
Mercer	--------	--------	3	3,319	--------	--------	2,219	24	1,075	3,319	1.68
Stark	--------	--------	3	121	--------	--------	--------	121	--------	121	1.43
Williams	--------	--------	1	4	--------	--------	--------	--------	4	4	3.00
Other counties [4]	--------	--------	8	860	--------	--------	595	125	141	860	2.08
Total [5]	--------	--------	22	4,487	--------	--------	2,950	315	1,221	4,487	1.78
Ohio:											
Columbiana	3	31	28	839	12	264	221	912	--------	1,133	3.33
Harrison	6	5,729	15	4,745	1	58	9,747	770	15	10,532	4.25
Hocking	--------	--------	9	131	--------	--------	--------	131	--------	131	3.87
Holmes	--------	--------	5	217	--------	--------	20	197	--------	217	3.37
Jackson	3	31	18	878	--------	--------	337	565	8	910	3.48
Meigs	1	10	2	34	1	5	15	34	--------	49	3.13
Stark	--------	--------	11	335	--------	--------	--------	335	--------	335	3.41
Vinton	2	5	8	222	--------	--------	6	221	--------	227	4.20
Wayne	--------	--------	1	27	--------	--------	--------	27	--------	27	3.25
Other counties [4]	40	10,532	166	23,089	40	1,138	21,983	9,939	2,842	34,763	3.92
Total [5]	55	16,339	263	30,516	54	1,468	32,328	13,129	2,866	48,328	3.96
Oklahoma:											
Craig	--------	--------	1	51	--------	--------	51	--------	--------	51	3.20
Muskogee	--------	--------	1	2	--------	--------	--------	2	--------	2	8.00
Other counties [4]	1	31	4	999	1	6	1,025	7	4	1,036	6.00
Total [5]	1	31	6	1,052	1	6	1,076	9	4	1,089	5.88

Pennsylvania:											
Allegheny	11	4,434	11	714	--------	--------	3,667	1,147	335	5,148	5.84
Armstrong	25	4,959	36	1,516	7	178	2,348	1,988	2,367	6,653	4.32
Bedford	3	81	2	4	--------	--------	--------	86	--------	86	3.73
Blair	1	3	--------	--------	--------	--------	--------	3	--------	3	6.45
Butler	9	742	30	1,117	7	87	1,222	723	1	1,946	4.08
Cambria	46	6,843	18	917	2	16	7,058	704	14	7,776	5.96
Centre	1	424	14	283	--------	--------	526	180	--------	706	4.19
Clearfield	18	1,430	58	4,616	7	114	3,791	2,368	1	6,160	3.93
Clinton	--------	--------	11	794	--------	--------	634	160	--------	794	3.83
Elk	5	53	11	254	5	51	196	163	--------	359	3.94
Fayette	6	219	22	290	--------	--------	244	236	30	509	5.42
Greene	18	11,663	3	25	--------	--------	11,638	42	9	11,688	6.88
Indiana	41	5,722	24	786	12	140	5,326	1,059	263	6,648	4.82
Jefferson	13	697	37	819	11	60	1,333	242	1	1,576	3.95
Lawrence	--------	--------	22	1,012	--------	--------	4	1,008	--------	1,012	3.49
Lycoming	--------	--------	3	60	--------	--------	--------	60	--------	60	4.25
Mercer	--------	--------	5	184	--------	--------	33	152	--------	184	3.44
Somerset	35	1,441	60	2,669	--------	--------	3,377	733	1	4,111	4.00
Venango	--------	--------	13	445	--------	--------	144	300	1	445	3.41
Westmoreland	12	2,703	20	245	--------	--------	2,124	511	313	2,948	5.69
Other counties [4]	17	13,208	89	4,162	4	20	13,922	3,450	18	17,390	5.94
Total [5]	261	54,622	489	20,912	55	667	57,587	15,261	3,352	76,200	5.37
Tennessee:											
Anderson	24	1,477	10	582	2	45	1,054	1,050	--------	2,104	3.48
Campbell	16	285	19	1,205	4	93	1,383	200	--------	1,583	3.69
Fentress	5	36	--------	--------	1	60	16	80	--------	96	3.57
Marion	25	1,003	--------	--------	--------	--------	787	216	--------	1,003	3.79
Morgan	9	97	9	276	--------	--------	--------	373	--------	373	3.88
Overton	6	32	--------	--------	--------	--------	24	9	--------	32	3.95
Rhea	2	19	--------	--------	--------	--------	--------	19	--------	19	4.19
Van Buren	1	1	5	286	--------	--------	266	21	--------	288	3.41
Other counties [4]	26	1,674	16	943	2	34	2,413	238	--------	2,652	3.66
Total [5]	114	4,624	59	3,292	9	232	5,944	2,204	--------	8,148	3.64
Utah:											
Carbon	11	3,062	--------	--------	--------	--------	2,888	163	11	3,062	6.00
Emery	8	1,167	--------	--------	--------	--------	990	172	6	1,167	5.17
Kane	1	2	--------	--------	--------	--------	--------	2	--------	2	5.96
Summit	1	13	--------	--------	--------	--------	--------	13	--------	13	5.09
Other counties [4]	2	73	--------	--------	--------	--------	--------	73	--------	73	5.71
Total [5]	23	4,316	--------	--------	--------	--------	3,878	421	17	4,316	5.77
Virginia:											
Buchanan	430	14,709	21	528	27	567	14,876	925	3	15,804	4.89
Dickenson	58	7,450	18	1,344	12	267	8,769	293	--------	9,062	5.02
Lee	34	810	10	307	9	110	844	383	--------	1,227	3.89
Russell	21	1,953	3	30	2	27	1,879	131	--------	2,010	5.12

See footnotes at end of table.

Table 18.—Production, shipments, and value at bituminous coal and lignite mines in the United States, in 1968, by States and counties—Continued

(Thousand short tons)

State and county	Production						Shipments				Average value per ton [3]
	Underground		Strip		Auger		Rail or water [1]	Truck	Used at mine [2]	Total	
	Number of mines	Quantity	Number of mines	Quantity	Number of mines	Quantity					
Virginia—Continued											
Tazewell	6	129	2	168	1	2	289	9	--------	298	4.25
Wise	107	6,337	32	1,670	14	548	7,851	491	211	8,554	4.66
Other counties [4]	2	11	--------	--------	--------	--------	2	9	--------	11	4.82
Total [5]	658	31,400	86	4,046	65	1,520	34,511	2,241	214	36,966	4.84
Washington:											
Lewis	--------	--------	2	128	--------	--------	--------	128	--------	128	2.91
Other counties [4]	3	50	--------	--------	--------	--------	10	40	--------	50	9.02
Total [5]	3	50	2	128	--------	--------	10	168	--------	178	4.63
West Virginia:											
Barbour	25	1,708	17	1,775	3	35	3,498	20	--------	3,518	4.23
Boone	42	7,857	12	1,271	19	1,162	10,249	28	13	10,290	5.04
Braxton	2	3	--------	--------	--------	--------	3	--------	--------	3	3.50
Brooke	3	692	4	95	1	19	51	87	667	806	3.79
Fayette	54	4,030	12	674	9	535	5,210	21	8	5,238	4.68
Gilmer	6	58	1	42	--------	--------	100	--------	--------	100	3.48
Greenbrier	33	684	--------	--------	--------	--------	648	36	--------	684	5.31
Kanawha	57	10,361	8	569	13	752	11,522	154	6	11,682	4.85
Lewis	1	10	4	270	1	19	289	10	--------	299	3.96
Logan	48	14,358	6	338	11	796	15,478	3	11	15,492	5.20
Marion	10	13,474	5	49	2	7	13,479	48	3	13,530	5.17
Marshall	4	3,412	--------	--------	--------	--------	1,653	120	1,638	3,412	4.46
Mason	4	259	2	85	1	4	265	51	32	348	3.57
McDowell	184	15,481	25	1,304	9	190	16,570	291	114	16,975	6.86
Mercer	17	1,187	3	118	2	12	1,292	23	3	1,317	6.84
Monongolia	27	10,016	9	205	1	6	9,925	302	--------	10,228	4.76
Nicholas	64	6,930	10	429	3	33	7,257	135	--------	7,392	5.62
Pocahontas	9	134	--------	--------	--------	--------	91	43	--------	134	4.01
Preston	43	1,285	17	960	--------	--------	1,587	658	--------	2,245	3.77
Raleigh	62	6,995	23	1,185	8	360	8,148	355	37	8,540	6.13
Randolph	15	449	5	49	2	13	489	21	--------	510	4.11
Taylor	9	60	5	59	--------	--------	116	3	--------	119	3.80
Upshur	8	287	8	264	1	6	529	27	--------	556	3.42
Webster	14	170	5	90	2	17	257	20	--------	277	3.63
Other counties [4]	193	28,965	39	2,251	21	1,008	30,979	1,213	33	32,226	5.28
Total [5]	934	128,866	220	12,081	109	4,974	139,687	3,668	2,566	145,921	5.32

Wyoming:											
Campbell			1	540			442	15	83	540	1.42
Sheridan			2	354			331	23		354	4.48
Other counties [4]	4	116	6	2,819			798	13	2,125	2,935	3.33
Total [5]	4	117	9	3,713			1,571	51	2,207	3,829	3.16
U.S. total [5]	3,381	344,142	1,492	185,836	454	15,267	463,328	61,753	20,165	545,245	4.67

---

[1] Includes coal loaded at mine directly into railroad cars or river barges, hauled by trucks to railroad sidings, and hauled by trucks to waterways.

[2] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

[3] Value received or charged for coal f.o.b. mine. Includes a value for coal not sold but used by producers, such as mine fuel and coal coked, as estimated by producers at average prices that might have been received if such coal had been sold commercially.

[4] Other counties. Alabama, underground: Bibb, Jackson, Marion, Shelby, Tuscaloosa; strip: Bibb, Blount, Cullman, Etowah, Fayette, Jackson, Marion, Tuscaloosa, Winston. Colorado, underground: Delta, Las Animas, Mesa, Moffat, Pitkin, Rio Blanco, Routt; strip: Mesa, Montrose, Routt. Illinois, underground: Christian, Douglas, Franklin, Gallatin, Jefferson, Logan, Macoupin, Mercer, Montgomery, Randolph, St. Clair, Saline, Washington; strip: Gallatin, Grundy, Knox, Peoria, Randolph, St. Clair, Saline, Stark, Will. Indiana, underground: Gibson, Knox, Pike, Sullivan, Vigo; strip: Daviess, Fountain, Gibson, Greene, Owen, Pike, Spencer, Sullivan, Vigo. Iowa, underground: Appanoose, Lucas, Monroe. Kansas, strip: Cherokee, Crawford. Kentucky, eastern, underground: Breathitt, Carter, Clay, Jackson, Lee, McCreary, Magoffin, Martin, Morgan, Pulaski; strip: Boyd, Breathitt, Clay, Jackson, Magoffin, Morgan, Pulaski; auger: Breathitt, Clay, Lawrence, Magoffin, Wayne. Kentucky, western, underground: Butler, Ohio, Union, Webster; strip: Butler, Daviess, Ohio, Webster; auger: Ohio. Maryland, underground: Allegany, Garrett; strip: Allegany, Garrett; auger: Allegany, Garrett. Missouri, strip: Boone, Henry, Macon. Montana, bituminous, underground: Blaine, Musselshell; strip: Big Horn, Rosebud. Montana, lignite, strip: Powder River, Richland. New Mexico, underground: Colfax, San Juan; strip: McKinley, San Juan. North Dakota, strip: Burke, Morton, Oliver, Ward. Ohio, underground: Athens, Belmont, Coshocton, Gallia, Guernsey, Jefferson, Monroe, Muskingum, Perry, Tuscarawas; strip: Athens, Belmont, Carroll, Coshocton, Gallia, Guernsey, Jefferson, Lawrence, Mahoning, Morgan, Muskingum, Noble, Perry, Tuscarawas, Washington; auger: Belmont, Carroll, Coshocton, Gallia, Guernsey, Jefferson, Muskingum, Noble, Perry, Tuscarawas. Oklahoma, underground: LeFlore; strip: Haskell, Rogers; auger: Haskell. Pennsylvania, underground: Beaver, Clarion, Huntingdon, Washington; strip: Beaver, Clarion, Huntingdon, Tioga, Washington; auger: Clarion, Washington. Tennessee, underground: Claiborne, Hamilton, Putnam, Scott, Sequatchie; strip: Bledsoe, Claiborne, Cumberland, Grundy, Hamilton, Scott, Sequatchie; auger: Claiborne, Scott. Utah, underground: Iron, Sevier. Virginia, underground: Montgomery, Scott. Washington, underground: King, Thurston. West Virginia, underground: Clay, Grant, Harrison, Mineral, Mingo, Ohio, Wayne, Wyoming; strip: Clay, Grant, Hancock, Harrison, Mineral, Mingo, Tucker, Wyoming; auger: Harrison, Mingo, Ohio, Wyoming. Wyoming, underground: Hot Springs, Sweetwater; strip: Carbon, Converse, Lincoln.

[5] Data may not add to totals shown because of independent rounding.

Table 19.—Number and production of bituminous coal and lignite strip mines and units of stripping and loading equipment in the United States, by States

State	Number of strip mines	Production (thousand short tons)	Number of power shovels and dragline excavators											Number of carryall scrapers	Number of bulldozers
			By type of power				By capacity of dipper or bucket, cubic yards				By type of machine		Total		
			Electric	Diesel electric	Diesel	Gasoline	Less than 3	3–5	6–12	More than 12	Power shovels	Dragline excavators			
1967															
Alabama	62	6,043	11	4	87	3	67	9	21	8	69	36	105	1	99
Alaska	4	925	------	------	10	------	6	4	-----	-----	9	1	10	8	14
Arkansas	4	144	------	3	4	------	4	1	2	-----	4	3	7	------	6
Colorado	7	1,862	8	1	5	------	3	3	5	3	7	7	14	2	15
Illinois	43	37,185	81	12	33	------	15	21	37	53	84	42	126	------	127
Indiana	37	17,131	49	5	41	9	38	18	28	20	63	41	104	------	85
Iowa	12	588	1	------	26	2	16	10	3	-----	13	16	29	3	25
Kansas	5	1,136	8	2	5	------	5	2	4	4	8	7	15	------	7
Kentucky:															
Eastern	66	5,503	------	4	98	2	62	39	3	-----	103	1	104	4	86
Western	38	30,282	51	5	57	2	27	24	38	26	75	40	115	1	114
Total [1]	104	35,785	51	9	155	4	89	63	41	26	178	41	219	5	200
Maryland	31	880	------	------	59	1	42	12	6	-----	44	16	60	------	33
Missouri	13	3,694	9	9	4	8	17	3	3	7	19	11	30	5	34
Montana:															
Bituminous	1	1	------	------	------	1	1	-----	-----	-----	1	------	1	------	------
Lignite	2	328	1	------	1	1	1	1	1	-----	2	1	3	2	2
Total [1]	3	329	1	------	1	2	2	1	1	-----	3	1	4	2	2
New Mexico	8	2,795	4	------	2	------	1	-----	3	2	5	1	6	1	9
North Dakota (lignite)	24	4,156	22	3	15	7	20	12	11	4	33	14	47	20	40
Ohio	278	29,209	43	17	460	16	322	111	72	31	384	152	536	28	459
Oklahoma	9	819	6	6	4	------	4	6	2	4	8	8	16	1	13
Pennsylvania	517	21,984	12	10	924	23	605	186	163	15	627	342	969	15	676
South Dakota (lignite)	1	5	------	1	1	------	1	1	-----	-----	1	1	2	------	1
Tennessee	58	2,677	------	3	82	1	71	4	11	-----	79	7	86	3	111
Virginia	70	4,196	------	2	106	3	92	18	1	-----	104	7	111	7	99
Washington	1	3	------	------	1	------	1	-----	-----	-----	1	------	1	1	1
West Virginia	217	12,117	1	9	319	5	263	51	17	3	300	34	334	9	341
Wyoming	9	3,471	5	------	12	1	9	4	4	1	14	4	18	18	24
Total [1]	1,507	187,134	312	96	2,356	85	1,693	540	435	181	2,057	792	2,849	129	2,421
1968															
Alabama	60	7,125	9	4	102	1	64	12	31	9	83	33	116	3	93
Alaska	3	750	------	------	6	------	3	3	-----	-----	5	1	6	6	6
Arkansas	6	152	------	1	6	------	4	1	2	-----	4	3	7	------	8

Colorado	5	1,795	7	1	5	------	3	3	4	3	9	4	13	------	12
Illinois	36	36,039	80	14	22	1	12	17	38	55	75	42	117	------	138
Indiana	35	16,318	49	5	39	8	34	18	22	27	61	40	101	1	109
Iowa	12	584	------	------	23	1	12	9	3	-----	11	13	24	2	19
Kansas	4	1,268	7	2	5	------	4	3	3	4	7	7	14	------	7
Kentucky:															
Eastern	82	5,801	1	2	106	6	88	22	5	-----	113	2	115	4	117
Western	41	28,432	53	4	49	1	21	19	34	33	72	35	107	9	133
Total [1]	123	34,233	54	6	155	7	109	41	39	33	185	37	222	13	250
Maryland	33	994	------	------	59	1	50	6	4	-----	45	15	60	------	41
Missouri	12	3,205	11	12	4	6	16	6	3	8	20	13	33	4	32
Montana:															
Bituminous	2	153	3	------	------	1	1	-----	1	2	3	1	4	------	1
Lignite	2	330	1	------	1	1	1	1	1	-----	2	1	3	2	2
Total [1]	4	483	4	------	1	2	2	1	2	2	5	2	7	2	3
New Mexico	3	2,662	6	------	2	------	1	1	3	3	5	3	8	4	6
North Dakota (lignite)	22	4,487	19	5	13	8	21	7	12	5	32	13	45	17	34
Ohio	263	30,516	45	24	407	17	272	116	68	37	361	132	493	30	461
Oklahoma	6	1,052	5	5	4	------	6	2	1	5	7	7	14	------	16
Pennsylvania	489	20,912	6	17	886	19	588	170	159	11	590	338	928	29	661
Tennessee	59	3,292	------	8	91	------	73	14	11	1	89	10	99	------	99
Virginia	86	4,046	------	------	90	------	65	24	1	-----	86	4	90	10	99
Washington	2	128	------	------	3	------	1	-----	2	-----	1	2	3	------	1
West Virginia	220	12,081	2	1	299	3	227	52	20	6	271	34	305	8	324
Wyoming	9	3,713	6	1	10	1	10	3	4	1	14	4	18	24	20
Total [1]	1,492	185,836	310	106	2,232	75	1,577	509	427	210	1,966	757	2,723	153	2,439

---

[1] Data may not add to totals shown because of independent rounding.

Table 20.—Bituminous coal and lignite strip mines using power drills in bank or overburden in the United States, by States

State	Number of mines		Production: Quantity (thousand short tons)		Number of power drills: Horizontal		Vertical		Total	
	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968
Alabama	35	33	4,789	5,264	8	7	32	32	40	39
Alaska	3	3	608	750	1	1	3	3	4	4
Arkansas	3	3	133	152	1	1	2	2	3	3
Colorado	6	4	1,861	1,764	5	2	6	5	11	7
Illinois	29	27	30,955	31,615	14	16	33	28	47	44
Indiana	26	23	16,749	15,851	15	12	22	30	37	42
Iowa	11	9	584	451	10	7	11	10	21	17
Kansas	5	4	1,136	1,268	11	9	1	2	12	11
Kentucky:										
Eastern	33	34	3,418	3,962	22	21	24	23	46	44
Western	32	29	29,534	27,965	10	8	43	48	53	56
Total [1]	65	63	32,952	31,927	32	29	67	71	99	100
Maryland	9	12	292	589	3	3	3	5	6	8
Missouri	11	10	3,682	3,199	13	12	5	5	18	17
Montana:										
Bituminous	1	1	1	2	----	----	1	1	1	1
Lignite	1	1	1	1	1	1	----	----	1	1
Total [1]	2	2	2	3	1	1	1	1	2	2
New Mexico	3	2	2,795	2,653	2	1	3	3	5	4
North Dakota (lignite)	2	1	1,226	2	1	1	3	----	4	1
Ohio	111	133	21,341	24,788	40	32	105	115	145	147
Oklahoma	6	4	815	999	6	5	5	4	11	9
Pennsylvania	198	193	13,337	12,828	58	61	148	133	206	194
Tennessee	32	32	1,980	1,934	27	27	20	14	47	41
Virginia	22	21	2,225	2,001	11	11	14	15	25	26
West Virginia	139	132	8,785	8,579	65	54	101	103	166	157
Wyoming	6	6	1,988	2,257	5	6	8	7	13	13
Total [1]	724	717	148,235	148,874	329	298	593	588	922	886

---

[1] Data may not add to totals shown because of independent rounding.

Table 21.—Method of haulage from bituminous coal and lignite strip mines to tipple or ramp, in the United States, by States

State	Strip mines reporting method of haulage: Number of trucks	Average capacity per truck (short tons)	Average distance hauled (miles)	Production (thousand short tons)	Strip mines not reporting method of haulage production (thousand short tons)	Total strip production (thousand short tons)
1967						
Alabama	109	26.2	5.2	3,620	2,423	6,043
Alaska	9	37.2	6.2	608	317	925
Arkansas	11	10.6	1.4	144	--------	144
Colorado	18	40.8	2.8	1,801	61	1,862
Illinois	313	51.5	3.9	36,914	271	37,185
Indiana	131	42.4	4.1	16,978	153	17,131
Iowa	29	12.7	4.5	584	4	588
Kansas	28	42.2	2.2	1,136	--------	1,136
Kentucky	372	31.6	4.5	30,327	5,458	35,785
Maryland	35	18.7	3.4	613	267	880
Missouri	59	35.7	4.6	3,664	30	3,694
Montana:						
Bituminous	1	10.0	.25	1	--------	1
Lignite	4	20.0	2.0	327	1	328
Total [1]	5	18.0	2.0	328	1	329
New Mexico	18	51.5	3.4	2,795	--------	2,795
North Dakota (lignite)	82	24.5	4.0	3,975	181	4,156
Ohio	685	23.3	7.4	23,648	5,561	29,209
Oklahoma	30	19.6	5.3	816	3	819
Pennsylvania	1,182	16.1	6.8	15,561	6,423	21,984
South Dakota (lignite)	1	6.0	4.0	5	--------	5
Tennessee	181	18.9	11.9	1,727	950	2,677
Virginia	95	18.4	3.8	2,121	2,075	4,196
Washington	1	5.0	.7	3	--------	3
West Virginia	630	19.6	5.3	8,911	3,206	12,117
Wyoming	34	26.9	1.5	3,471	--------	3,471
Total [1]	4,058	24.3	5.0	159,750	27,384	187,134
1968						
Alabama	88	25.1	4.1	3,997	3,128	7,125
Alaska	13	43.2	6.4	750	--------	750
Arkansas	11	10.6	1.7	145	7	152
Colorado	18	40.8	2.9	1,695	100	1,795
Illinois	288	56.3	4.0	35,998	41	36,039
Indiana	155	48.7	4.8	16,158	160	16,318
Iowa	29	12.7	5.0	547	37	584
Kansas	26	42.2	3.4	1,268	--------	1,268
Kentucky	343	33.8	5.4	26,079	8,154	34,233
Maryland	31	17.8	4.9	621	373	994
Missouri	54	37.2	5.7	3,178	27	3,205
Montana:						
Bituminous	1	10.0	.5	2	151	153
Lignite	6	13.7	2.0	330	--------	330
Total [1]	7	13.1	2.0	332	151	483
New Mexico	16	61.8	3.3	2,652	10	2,662
North Dakota (lignite)	77	23.3	3.3	4,305	182	4,487
Ohio	703	24.9	7.2	26,236	4,280	30,516
Oklahoma	22	21.6	4.8	1,052	--------	1,052
Pennsylvania	1,095	16.7	7.3	15,237	5,675	20,912
Tennessee	138	19.5	12.2	1,623	1,669	3,292
Virginia	99	19.9	5.4	2,122	1,924	4,046
Washington	12	9.5	1.0	128	--------	128
West Virginia	543	20.1	5.3	8,555	3,526	12,081
Wyoming	34	32.1	1.8	3,713	--------	3,713
Total [1]	3,802	26.0	5.3	156,391	29,444	185,836

---

[1] Data may not add to totals shown because of independent rounding.

Table 22.—Equipment used at bituminous coal and lignite auger mines in the United States, number of units

State	Augers		Power shovels		Power drills		Bulldozers	
	1967	1968	1967	1968	1967	1968	1967	1968
Alabama	4	2	------	------	------	------	------	------
Colorado	2	------	------	------	------	------	------	------
Illinois	------	1	------	------	------	------	------	------
Kentucky	146	150	5	2	10	5	104	99
Maryland	3	5	------	------	------	------	2	2
Ohio	50	41	3	1	1	1	34	22
Oklahoma	1	1	------	------	------	------	------	------
Pennsylvania	62	49	------	------	14	4	9	6
Tennessee	9	9	------	2	------	------	2	6
Virginia	67	68	------	------	5	6	41	49
West Virginia	106	107	11	18	5	16	113	109
Total	450	433	19	23	35	32	305	293

Table 23.—Bituminous coal and lignite mechanically loaded underground in the United States, by type of loading equipment

Type of loading equipment	1967	1968
Mobile loading machines:		
Direct into mine cars or onto conveyors	20,965	21,380
Into shuttle cars	137,461	138,320
Continuous-mining machines:		
Onto conveyors	17,201	17,433
Into shuttle cars	125,277	118,183
Onto bottom	20,228	24,196
Into rubber-tired mine cars	2,865	4,004
Longwall machines	3,232	4,633
Duckbills, scraper loaders, and hand-loaded conveyors	2,685	1,239
Total mechanically loaded [1]	329,914	329,387

[1] Data may not add to totals shown because of independent rounding.

Table 24.—Comparative changes in underground mechanical loading of bituminous coal and lignite by principal types of loading devices in the United States, by States

State	Mobile loading machines		Continuous-mining machines		Longwall machines	
	1967	1968	1967	1968	1967	1968
Alabama	8,493	8,418	284	382	--------	--------
Arkansas	--------	--------	--------	--------	--------	--------
Colorado	888	918	2,617	2,786	--------	--------
Illinois	12,797	12,221	15,037	14,168	110	--------
Indiana	1,591	1,989	49	179	--------	--------
Iowa	286	289	--------	--------	--------	--------
Kentucky	40,894	44,071	9,195	10,544	--------	--------
Maryland	154	161	116	95	--------	--------
Montana	21	17	--------	--------	--------	--------
New Mexico	--------	--------	660	763	--------	--------
Ohio	6,460	6,710	8,492	9,475	--------	--------
Oklahoma	--------	--------	--------	31	--------	--------
Pennsylvania	9,065	9,068	45,844	43,391	820	1,615
Tennessee	2,519	3,246	513	606	--------	--------
Utah	948	871	2,882	3,149	331	282
Virginia	14,693	15,540	9,065	10,411	518	990
Washington	17	19	--------	--------	--------	--------
West Virginia	59,493	56,052	70,817	67,835	1,453	1,746
Wyoming	109	110	--------	--------	--------	--------
Total [1]	158,426	159,700	165,571	163,816	3,232	4,633

State	Duckbills, scraper loaders, and hand-loaded conveyors		Total mechanically loaded		Total production at mines using mechanical loading devices	
	1967	1968	1967	1968	1967	1968
Alabama	315	165	9,092	8,966	9,100	8,966
Arkansas	45	59	45	59	45	59
Colorado	48	43	3,552	3,747	3,552	3,751
Illinois	--------	--------	27,945	26,389	27,945	26,389
Indiana	--------	--------	1,639	2,168	1,639	2,168
Iowa	--------	--------	286	289	286	289
Kentucky	28	37	50,117	54,653	50,517	55,042
Maryland	3	3	273	259	273	259
Montana	17	16	38	33	38	33
New Mexico	1	--------	661	763	661	763
Ohio	9	10	14,961	16,195	14,961	16,197
Oklahoma	2	--------	2	31	2	31
Pennsylvania	294	211	56,022	54,285	56,090	54,286
Tennessee	177	125	3,209	3,977	3,209	3,977
Utah	13	13	4,175	4,316	4,175	4,316
Virginia	82	87	24,358	27,028	24,866	27,156
Washington	39	31	56	50	56	50
West Virginia	1,604	433	133,366	126,066	133,417	126,159
Wyoming	9	7	117	117	117	117
Total [1]	2,685	1,239	329,914	329,887	330,951	330,005

---

[1] Data may not add to totals shown because of independent rounding.

Table 25.—Number of bituminous coal and lignite underground mines using mechanical loading devices and number of units in use in the United States, by States

State	Number of mines									
	Using mobile loading machines		Using continuous-mining machines only		Using duckbills, scraper loaders, and hand-loaded conveyors only		Using more than one type of loading device		Total	
	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968
Alabama	12	10	-----	-----	23	19	5	4	40	33
Arkansas	-----	-----	-----	-----	3	2	-----	-----	3	2
Colorado	22	22	9	10	7	6	7	5	45	43
Illinois	18	14	5	10	-----	-----	8	8	31	32
Indiana	9	8	-----	-----	-----	-----	1	1	10	9
Iowa	2	2	-----	-----	-----	-----	-----	-----	2	2
Kentucky	407	425	31	41	1	2	12	11	451	479
Maryland	2	2	2	2	1	1	-----	-----	5	5
Montana	4	3	-----	-----	2	2	-----	-----	6	5
New Mexico	-----	-----	1	1	1	-----	-----	-----	2	1
Ohio	18	14	9	12	2	2	4	5	33	33
Oklahoma	-----	-----	-----	1	1	-----	-----	-----	1	1
Pennsylvania	47	41	109	108	35	24	22	21	213	194
Tennessee	31	31	4	6	15	12	-----	-----	50	49
Utah	11	10	9	7	1	1	3	5	24	23
Virginia	276	269	43	40	4	6	16	18	339	333
Washington	2	2	-----	-----	1	1	-----	-----	3	3
West Virginia	355	341	128	147	19	15	112	108	614	606
Wyoming	2	4	-----	-----	3	-----	-----	-----	5	4
Total	1,218	1,198	350	385	119	93	190	181	1,877	1,857

State	Number of loading devices							
	Mobile loading machines		Continuous-mining machines		Longwall machines		Duckbills, scraper loaders, and hand-loaded conveyors	
	1967	1968	1967	1968	1967	1968	1967	1968
Alabama	78	77	6	7	------	------	67	28
Arkansas	-------	-------	-------	-------	------	------	10	4
Colorado	61	58	35	36	------	------	15	13
Illinois	75	77	65	76	2	------	-------	-------
Indiana	24	25	1	1	------	------	-------	-------
Iowa	4	5	-------	-------	------	------	-------	-------
Kentucky	631	643	92	108	------	------	1	3
Maryland	4	5	3	3	------	------	1	1
Montana	9	7	-------	-------	------	------	6	6
New Mexico	3	4	3	4	------	------	1	-------
Ohio	56	56	66	75	------	------	3	3
Oklahoma	-------	-------	-------	1	------	------	1	-------
Pennsylvania	237	222	449	429	3	8	70	53
Tennessee	51	56	8	10	------	------	33	23
Utah	42	32	29	27	1	2	2	2
Virginia	316	335	94	98	3	4	6	10
Washington	2	3	-------	-------	------	------	3	3
West Virginia	921	933	561	612	6	8	74	52
Wyoming	4	4	-------	-------	------	------	6	5
Total	2,518	2,542	1,412	1,487	15	22	299	206

Table 26.—Production at bituminous coal and lignite underground mines in the United States, by States and methods of loading

(Thousand short tons)

State	Hand loaded		Mechanically loaded		Total underground production	
	1967	1968	1967	1968	1967	1968
Alabama	270	286	9,092	8,966	9,362	9,252
Arizona	1	----------	----------	----------	1	----------
Arkansas	----------	----------	45	59	45	59
Colorado	22	16	3,552	3,747	3,574	3,763
Illinois	3	3	27,945	26,389	27,948	26,392
Indiana	2	----------	1,639	2,168	1,641	2,168
Iowa	9	4	286	289	295	293
Kentucky	8,401	6,041	50,117	54,653	58,518	60,694
Maryland	108	95	273	259	381	354
Missouri	1	----------	----------	----------	1	----------
Montana	4	3	38	33	42	36
New Mexico	7	5	661	763	668	768
Ohio	211	144	14,961	16,195	15,172	16,339
Oklahoma	----------	----------	2	31	2	31
Pennsylvania	468	337	56,022	54,285	56,490	54,622
Tennessee	745	647	3,209	3,977	3,954	4,624
Utah	----------	----------	4,175	4,316	4,175	4,316
Virginia	6,142	4,372	24,358	27,028	30,500	31,400
Washington	----------	----------	56	50	56	50
West Virginia	2,827	2,800	133,366	126,066	136,193	128,866
Wyoming	----------	----------	117	117	117	117
Total [1]	19,219	14,755	329,914	329,387	349,133	344,142

---

[1] Data may not add to totals shown because of independent rounding.

Table 27.—Mechanical cleaning at bituminous coal and lignite mines in the United States, by States

State	1967					1968				
	Total production	Mechanical cleaning				Total production	Mechanical cleaning			
		Number of cleaning plants	Raw coal	Cleaned coal	Refuse		Number of cleaning plants	Raw coal	Cleaned coal	Refuse
Alabama	15,486	26	18,710	11,297	7,413	16,440	22	19,070	11,655	7,415
Alaska	925	4	564	344	220	750	3	52	29	23
Arkansas	189	(1)	(1)	(1)	(1)	211	1	63	58	5
Colorado	5,439	4	2,946	2,596	350	5,558	3	1,962	1,706	255
Illinois	65,133	45	64,812	52,522	12,290	62,441	48	65,529	53,881	11,648
Indiana	18,772	11	18,763	15,110	3,654	18,486	12	19,397	15,324	4,074
Kansas	1,136	4	1,618	1,129	488	1,268	3	1,762	1,262	500
Kentucky	100,294	57	61,203	50,284	10,919	101,156	52	61,780	50,246	11,535
Missouri	3,696	5	2,865	2,189	676	3,205	5	2,877	1,860	1,017
New Mexico	3,463	1	823	660	163	3,429	1	905	741	164
Ohio	46,014	20	21,734	17,249	4,485	48,323	20	21,445	16,942	4,504
Oklahoma	823	1	176	139	37	1,089	3	265	203	62
Pennsylvania	79,412	91	68,517	52,191	16,327	76,200	85	63,389	48,541	14,848
Tennessee	6,832	2	701	505	196	8,148	4	1,335	1,036	298
Utah	4,175	5	3,102	2,696	406	4,316	6	3,129	2,752	377
Virginia	36,721	37	23,483	18,525	4,959	36,966	33	25,185	19,663	5,521
Washington	59	2	67	56	11	178	3	60	50	10
West Virginia	153,749	154	157,811	121,788	36,023	145,921	149	149,748	114,900	34,848
Wyoming	3,588	[2] 2	[2] 129	[2] 122	[2] 7	3,829	1	77	74	3
Other States [3]	6,721	------	------	------	------	7,329	------	------	------	------
Total [4]	552,626	471	448,024	349,402	98,624	545,245	454	438,030	340,923	97,107

---

[1] Included in Wyoming.

[2] Includes Arkansas.

[3] Includes Arizona (1967), Iowa, and Maryland, and bituminous and lignite from Montana, North Dakota, and South Dakota (1967).

[4] Data may not add to totals shown because of independent rounding.

Table 28.—Mechanical cleaning of bituminous coal and lignite in the United States, by types of equipment

(Thousand short tons)

Type of equipment	1967	1968
Wet methods:		
Jigs	161,302	159,028
Concentrating tables	49,529	47,268
Classifiers	3,902	4,871
Launders	4,627	4,498
Dense medium processes:		
Magnetite	66,014	70,633
Sand	32,513	27,027
Calcium chloride	2,514	1,839
Total [1]	101,043	99,497
Flotation	7,732	8,961
Total, wet methods [1]	328,135	324,123
Pneumatic methods	21,268	16,804
Grand total [1]	349,402	340,923

[1] Data may not add to totals shown because of independent rounding.

Table 29.—Mechanical cleaning at bituminous coal and lignite mines in the United States, by States and by underground, strip, and auger mining

(Thousand short tons)

State	Underground mines		Strip mines		Auger mines		Total, all mines [1]	
	Total production	Cleaned	Total production	Cleaned	Total production	Cleaned	Total production	Cleaned
1967								
Alabama	9,362	8,888	6,043	2,380	81	30	15,486	11,297
Alaska	-------	-------	925	344	-------	-------	925	344
Arkansas	45	(2)	144	(2)	-------	-------	189	(2)
Colorado	3,574	2,596	1,862	-------	4	-------	5,439	2,596
Illinois	27,948	20,237	37,185	32,285	-------	-------	65,133	52,522
Indiana	1,641	1,348	17,131	13,762	-------	-------	18,772	15,110
Kansas	-------	-------	1,136	1,129	-------	-------	1,136	1,129
Kentucky	58,518	29,157	35,785	21,127	5,990	-------	100,294	50,284
Missouri	1	-------	3,694	2,189	-------	-------	3,696	2,189
New Mexico	668	660	2,795	-------	-------	-------	3,463	660
Ohio	15,172	11,483	29,209	5,604	1,633	162	46,014	17,249
Oklahoma	2	-------	819	137	2	2	823	139
Pennsylvania	56,490	44,625	21,984	7,371	938	194	79,412	52,191
Tennessee	3,954	505	2,677	-------	202	-------	6,832	505
Utah	4,175	2,696	-------	-------	-------	-------	4,175	2,696
Virginia	30,500	17,821	4,196	487	2,025	218	36,721	18,525
Washington	56	56	3	-------	-------	-------	59	56
West Virginia	136,193	116,424	12,117	3,776	5,440	1,588	153,749	121,788
Wyoming	117	[3] 73	3,471	[3] 49	-------	-------	3,588	[3] 122
Other States [4]	719	-------	5,958	-------	45	-------	6,721	-------
Total [1]	349,133	256,569	187,134	90,640	16,360	2,194	552,626	349,402
1968								
Alabama	9,252	8,790	7,125	2,846	63	19	16,440	11,655
Alaska	-------	-------	750	29	-------	-------	750	29
Arkansas	59	-------	152	58	-------	-------	211	58
Colorado	3,763	1,706	1,795	-------	-------	-------	5,558	1,706
Illinois	26,392	20,825	36,039	33,057	10	-------	62,441	53,881
Indiana	2,168	1,822	16,318	13,502	-------	-------	18,486	15,324
Kansas	-------	-------	1,268	1,262	-------	-------	1,268	1,262
Kentucky	60,694	30,904	34,233	19,342	6,229	-------	101,156	50,246
Missouri	-------	-------	3,205	1,860	-------	-------	3,205	1,860
New Mexico	768	741	2,662	-------	-------	-------	3,429	741
Ohio	16,339	12,235	30,516	4,654	1,468	53	48,323	16,942
Oklahoma	31	31	1,052	166	6	6	1,089	203
Pennsylvania	54,622	41,947	20,912	6,470	667	124	76,200	48,541
Tennessee	4,624	1,036	3,292	-------	232	-------	8,148	1,036
Utah	4,316	2,752	-------	-------	-------	-------	4,316	2,752
Virginia	31,400	19,052	4,046	510	1,520	102	36,966	19,663
Washington	50	50	128	-------	-------	-------	178	50
West Virginia	128,866	108,869	12,081	3,774	4,974	2,257	145,921	114,900
Wyoming	117	74	3,713	-------	-------	-------	3,829	74
Other States [4]	683	-------	6,548	-------	99	-------	7,329	-------
Total [1]	344,142	250,834	185,836	87,530	15,267	2,561	545,245	340,923

---

[1] Data may not add to totals shown because of independent rounding.
[2] Included in Wyoming.
[3] Includes Arkansas.
[4] Includes Arizona (1967), Iowa, Maryland, and bituminous and lignite from Montana, North Dakota, and South Dakota (1967).

Table 30.—Mechanical crushing of bituminous coal and lignite at mines in the United States, by States

State	Number of plants crushing coal		Coal crushed (thousand short tons)	
	1967	1968	1967	1968
Alabama	24	16	6,930	7,367
Alaska	3	3	608	750
Arkansas	5	6	143	189
Colorado	35	29	3,302	3,306
Illinois	67	63	34,840	37,998
Indiana	30	31	14,574	14,130
Iowa	15	13	616	701
Kansas	1	1	882	978
Kentucky	154	126	50,835	54,871
Maryland	10	6	594	591
Missouri	9	9	3,617	3,167
Montana:				
Bituminous	6	8	16	170
Lignite	2	2	326	328
Total [1]	8	10	342	499
New Mexico	4	4	3,443	3,421
North Dakota (lignite)	17	16	3,989	4,341
Ohio	114	107	24,228	25,278
Oklahoma	5	5	696	938
Pennsylvania	189	165	38,410	37,171
South Dakota (lignite)	1	----------	2	----------
Tennessee	33	37	2,314	3,442
Utah	19	21	2,310	2,609
Virginia	67	55	14,632	13,452
Washington	3	3	8	9
West Virginia	261	226	53,608	53,064
Wyoming	9	9	3,449	1,768
Total [1]	1,083	961	264,372	270,040

[1] Data may not add to totals shown because of independent rounding.

Table 31.—Treatment of bituminous coal and lignite at mines for allaying dust in the United States

Treatment	Thousand short tons [1]		Number of plants [2]	
	1967	1968	1967	1968
Calcium chloride	2,987	875	32	24
Oil	45,177	44,120	428	382
Calcium chloride and oil	1,961	1,893	18	14
All other materials	10,275	12,388	31	23
Total	60,400	59,276	509	443

[1] Data may not add to totals shown because of independent rounding.

[2] Because some mines used more than 1 method of treatment, this total may not necessarily be the sum of the individual items.

Table 32.—Treatment of bituminous coal and lignite at mines for allaying dust in the United States, by States

State	Number of mines treating coal		Coal treated (thousand short tons)	
	1967	1968	1967	1968
Alabama	1	1	1	2
Colorado	27	24	208	187
Illinois	47	43	4,345	3,502
Indiana	17	16	589	625
Iowa	2	3	4	4
Kansas	3	2	16	17
Kentucky	63	53	9,394	13,991
Missouri	2	2	13	11
Montana:				
Bituminous	7	7	21	19
Lignite	1	1	1	1
Total [1]	8	8	22	19
New Mexico	3	3	2,781	2,657
North Dakota (lignite)	17	16	475	452
Ohio	26	25	4,957	3,275
Oklahoma	3	2	13	11
Pennsylvania	63	48	12,425	10,758
South Dakota (lignite)	1	----------	2	----------
Tennessee	2	1	20	22
Utah	17	17	807	827
Virginia	25	23	5,958	5,088
West Virginia	122	100	18,222	17,681
Wyoming	9	9	148	152
Total [1]	458	396	60,400	59,276

[1] Data may not add to totals shown because of independent rounding.

Table 33.—Thermal drying of bituminous coal and lignite in the United States, by type of drying equipment

Type of drier	Number of thermal drying units		Thermally dried (thousand short tons)	
	1967	1968	1967	1968
Fluidized-bed	67	77	38,102	38,158
Multilouver	49	42	15,090	13,831
Rotary	5	6	1,668	1,995
Screen	35	33	5,994	5,897
Suspension or flash	42	40	9,853	9,202
Vertical tray and cascade	35	23	4,036	4,225
Total [1]	233	221	74,741	73,308

[1] Data may not add to totals shown because of independent rounding.

Table 34.—Comparison of thermal drying of bituminous coal and lignite with mechanical cleaning at mines in the United States, by States

(Thousand short tons)

State	Number of cleaning plants				Production mechanically cleaned		Thermally dried	
	Total		With thermal drying					
	1967	1968	1967	1968	1967	1968	1967	1968
Colorado	------	3	------	1	--------	1,706	--------	702
Illinois	45	48	25	25	52,522	53,881	12,557	11,848
Indiana	11	12	7	6	15,110	15,324	2,544	2,294
Kentucky	57	52	11	9	50,284	50,246	3,335	3,350
North Dakota (lignite)	------	------	3	2	--------	--------	178	135
Ohio	20	20	9	7	17,249	16,942	3,920	3 204
Pennsylvania	91	85	13	11	52,191	48,541	6,547	5,717
Utah	5	6	2	2	2,696	2,752	1,092	920
Virginia	37	33	7	7	18,525	19,663	9,084	9,633
West Virginia	154	149	55	55	121,788	114,900	35,484	35,500
Other States	51	46	------	------	19,037	16,968	--------	--------
Total [1]	471	454	132	125	349,402	340,923	74,741	73,303

[1] Data may not add to totals shown because of independent rounding.

Table 35.—Thermal drying of bituminous coal and lignite at mines in the United States, by States

(Thousand short tons)

State	Number of thermal drying units		Grand total production		Thermally dried	
	1967	1968	1967	1968	1967	1968
Colorado	----------	1	----------	5,558	----------	702
Illinois	47	46	65,133	62,441	12,557	11,848
Indiana	10	8	18,772	18,486	2,544	2,294
Kentucky	20	18	100,294	101,156	3,335	3,350
North Dakota (lignite)	3	2	4,156	4,487	178	135
Ohio	16	14	46,014	48,323	3,920	3,204
Pennsylvania	18	16	79,412	76,200	6,547	5,717
Utah	2	2	4,175	4,316	1,092	920
Virginia	19	19	36,721	36,966	9,084	9,633
West Virginia	98	95	153,749	145,921	35,484	35,500
Other States	----------	----------	44,201	41,389	----------	----------
Total [1]	233	221	552,626	545,245	74,741	73,303

[1] Data may not add to totals shown because of independent rounding.

Table 36.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, as reported by mine operators

(Thousand short tons)

Route	State	1967		1968	
		By State	Total for route	By State	Total for route
RAILROAD					
Alaska	Alaska	913	913	745	745
Atchison, Topeka & Santa Fe	Illinois	123	1,097	190	1,341
	New Mexico	974		1,151	
Baltimore & Ohio	Illinois	538	38,644	447	34,838
	Maryland	2		-------	
	Ohio	7,888		8,156	
	Pennsylvania	2,701		2,138	
	West Virginia	27,515		24,097	

Table 36.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, as reported by mine operators—Continued

(Thousand short tons)

Route	State	1967		1968	
		By State	Total for route	By State	Total for route
Bessemer & Lake Erie	Pennsylvania	2,557	2,557	2,012	2,012
Cambria & Indiana	do	4,782	4,782	5,985	5,985
Carbon County	Utah	837	837	788	788
Chesapeake & Ohio	Kentucky	16,840	57,372	15,862	55,893
	Ohio	10		6	
	West Virginia	40,522		40,025	
Cheswick & Harmar	Pennsylvania	329	329	322	322
Chicago, Burlington & Quincy	Illinois	9,832	11,734	9,874	11,706
	Iowa	289		332	
	Missouri	878		726	
	Wyoming	735		774	
Chicago & Eastern Illinois	Illinois	2,692	3,292	2,052	3,029
	Indiana	600		977	
Chicago & Illinois Midland	Illinois	3,613	3,613	4,726	4,726
Chicago, Milwaukee, St. Paul & Pacific	Indiana	1,580	1,671	2,404	2,541
	North Dakota (lig.)	91		137	
Chicago & North Western	Illinois	2,206	2,206	1,858	1,858
Chicago, Rock Island & Pacific	do	1,195	1,425	1,744	1,939
	Iowa	230		195	
Clinchfield	Kentucky	728	6,030	842	5,619
	Virginia	5,302		4,777	
Colorado & Wyoming	Colorado	744	744	764	764
Denver & Rio Grande Western	do	2,804	4,830	2,967	4,939
	Utah	2,026		1,972	
Erie- Lackawanna	Ohio	166	166	221	221
Great Northern	North Dakota (lig.)	248	248	195	195
Gulf, Mobile & Ohio	Illinois	7,619	7,619	7,214	7,214
Illinois Central	do	14,971	27,884	13,113	24,673
	Kentucky	12,913		11,560	
Illinois Terminal	Illinois	289	289	197	197
Interstate	Virginia	5,310	5,310	5,250	5,250
Kansas City Southern	Missouri	15	126	22	188
	Oklahoma	111		166	
Kentucky & Tennessee	Kentucky	530	530	527	527
Lake Erie, Franklin & Clarion	Pennsylvania	287	287	361	361
Louisville & Nashville	Alabama	1,830	36,939	2,123	36,515
	Kentucky	33,304		32,419	
	Tennessee	1,506		1,661	
	Virginia	299		312	
Mary Lee	Alabama	846	846	920	920
Midland Valley	Oklahoma	194	194	-----	-------
Missouri-Kansas-Texas	Kansas	785	1,236	978	1,488
	Missouri	404		459	
	Oklahoma	47		51	
Missouri Pacific	Arkansas	178	6,095	206	4,927
	Illinois	5,856		4,490	
	Missouri	61		34	
	Oklahoma	-------		197	
Monongahela	Pennsylvania	51	10,372	-------	9,896
	West Virginia	10,321		9,896	
Montour	Pennsylvania	2,365	2,365	2,362	2,362
Norfolk & Western	Iowa	103	81,442	86	80,794
	Kentucky	7,833		10,910	
	Missouri	598		387	
	Ohio	7,117		7,331	
	Virginia	21,953		22,506	
	West Virginia	43,838		39,574	
Northern Pacific	Montana (bit. and lig.).	330	2,195	484	2,704
	North Dakota (lig.)	1,865		2,220	

See footnotes at end of table.

Table 36.—Bituminous coal and lignite loaded for shipment by railroads and waterways in the United States, as reported by mine operators—Continued

(Thousand short tons)

Route	State	1967		1968	
		By State	Total for route	By State	Total for route
Pacific Coast	Washington	18	18	10	10
Penn Central [1] (includes coal shipped over Kanawha & Michigan, Kelley's Creek, Toledo & Ohio Central, and Zanesville & Western).	Illinois	3,906	23,216	3,422	51,791
	Indiana	6,862		9,089	
	Ohio	3,332		12,391	
	Pennsylvania	4,115		21,609	
	West Virginia	5,001		5,280	
Pennsylvania	Indiana	3,037	29,819	(2)	(2)
	Ohio	7,085			
	Pennsylvania	19,747			
Pittsburgh & Lake Erie	Pennsylvania	1,097	1,097	-------	-------
Pittsburgh & Shawmut	----do	2,127	2,127	1,958	1,958
St. Louis-San Francisco	Alabama	110	808	320	1,251
	Arkansas	11		2	
	Kansas	231		267	
	Oklahoma	456		662	
Soo Line	North Dakota (lig.)	420	420	398	398
Southern	Alabama	3,008	5,853	3,419	8,733
	Indiana	20		12	
	Kentucky	366		733	
	Tennessee	1,622		2,902	
	Virginia	837		1,667	
Tennessee	Tennessee	804	804	685	685
Tennessee Central	----do	146	146	60	60
Tennessee Coal, Iron & Railroad Co	Alabama	2,027	2,027	1,977	1,977
Toledo, Peoria & Western	Illinois	712	712	634	634
Union Pacific	Colorado	438	1,174	445	1,242
	Wyoming	736		797	
Unity	Pennsylvania	416	416	788	788
Utah	Utah	861	861	1,118	1,118
Western Allegheny	Pennsylvania	132	132	-------	-------
Western Maryland	Maryland	746	7,646	808	7,374
	Pennsylvania	498		368	
	West Virginia	6,402		6,198	
Woodward Iron Company	Alabama	1,032	1,032	952	952
Total railroad shipments [3]		404,525	404,525	396,443	396,443
WATERWAY					
Allegheny River	Pennsylvania	1,355	1,355	1,115	1,115
Black Warrior River	Alabama	2,850	2,850	3,022	3,022
Cumberland River	Kentucky	171	171	140	140
Green River	----do	13,128	13,128	15,136	15,136
Illinois River	Illinois	2,690	2,690	2,599	2,599
Kanawha River	West Virginia	5,460	5,460	5,249	5,249
Mississippi River	Illinois	136	136	41	41
Monongahela River	Pennsylvania	19,462	26,340	18,568	24,598
	West Virginia	6,878		6,030	
Ohio River	Illinois	398	13,613	1,035	13,786
	Indiana	1,831		1,177	
	Kentucky	4,976		4,011	
	Ohio	3,908		4,223	
	West Virginia	2,500		3,340	
Tennessee River	Alabama	618	1,229	563	1,199
	Tennessee	611		636	
Total waterway shipments [3]		66,972	66,972	66,885	66,885
Total loaded at mines for shipment by railroads and waterways.		471,497	471,497	463,328	463,328
Shipped by truck from mine to final destination.		62,003	62,003	61,753	61,753
Used at mine [4]		19,127	19,127	20,165	20,165
Total production [3]		552,626	552,626	545,245	545,245

[1] 1967 data are for New York Central Railroad, which merged in 1968 with the Pennsylvania Railroad to form the Penn Central System.

[2] Merged in 1968 with New York Central Railroad to form the Penn Central System

[3] Data may not add to totals shown because of independent rounding.

[4] Includes coal used at mine for power and heat, made into beehive coke at mine, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor, tram, or pipeline.

Table 37.—Bituminous coal and lignite shipped by unit train in the United States

(Thousand short tons)

State	1967	1968	State	1967	1968
Colorado	-------	731	Montana	-------	1
Illinois	14,308	13,363	Ohio	6,770	10,477
			Pennsylvania	16,746	18,054
Kentucky:			Virginia	4,843	5,372
Eastern	6,061	8,537	West Virginia	45,779	42,289
Western	3,263	4,864	Other States [2]	4,560	5,435
Total [1]	9,324	13,401	Total [1]	102,330	109,125

[1] Data may not add to totals shown because of independent rounding.
[2] Other States includes Alabama, Indiana, Kansas, Maryland, New Mexico, North Dakota (lignite), Tennessee (1968), Utah (1968), and Wyoming (1967).

Table 38.—Consumption of bituminous coal and lignite, by consumer class, with retail deliveries in the United States

(Thousand short tons)

Year and month	Electric power utilities [1]	Bunker, lake vessel and foreign [2]	Manufacturing and mining industries					Retail deliveries to other consumers [5]	Total of classes shown [6]
			Beehive coke plants	Oven coke plants	Steel and rolling mills [3]	Cement mills	Other manufacturing and mining industries [4]		
1964	223,032	711	2,025	86,732	7,394	8,679	82,928	19,615	431,116
1965	242,729	655	2,693	92,086	7,466	8,873	85,614	19,048	459,164
1966	264,202	609	2,369	93,523	7,117	9,149	89,332	19,965	486,266
1967:									
January	24,723	1	199	7,760	716	692	8,335	2,610	45,036
February	22,758	------	152	7,109	661	647	7,643	2,550	41,520
March	22,910	4	103	7,890	633	732	7,773	1,680	41,725
April	20,955	47	99	7,520	518	701	6,809	729	37,378
May	21,543	69	96	7,754	513	789	6,707	693	38,164
June	22,318	69	90	7,251	424	688	6,331	433	37,604
July	21,999	53	78	7,303	396	681	5,755	473	36,738
August	22,922	61	98	7,445	413	703	6,313	895	38,850
September	21,133	56	93	7,358	418	767	6,010	1,811	37,146
October	22,528	55	120	7,723	494	795	6,821	1,592	40,128
November	23,364	43	122	7,731	552	943	7,339	1,985	42,079
December	24,631	9	122	8,056	592	784	7,706	2,148	44,048
Total	271,784	467	1,372	90,900	6,330	8,922	83,542	17,099	480,416
1968:									
January	26,646	1	120	7,975	645	754	8,423	2,780	47,344
February	25,115	------	113	7,634	611	803	7,867	2,380	44,523
March	24,346	3	131	8,082	571	702	7,623	1,730	43,188
April	21,929	43	134	7,870	492	754	6,739	773	38,734
May	22,574	57	135	8,122	476	856	6,584	471	39,275
June	23,209	49	118	7,840	407	747	6,011	475	38,856
July	25,126	46	103	7,835	381	741	5,819	465	40,516
August	26,530	61	97	7,198	336	748	5,807	681	41,458
September	22,850	54	85	6,561	325	771	5,882	943	37,471
October	23,764	48	76	6,524	390	777	6,700	1,357	39,636
November	24,781	41	78	6,632	449	828	7,209	1,339	41,357
December	27,869	14	78	7,224	574	910	7,973	1,830	46,472
Total	294,739	417	1,268	89,497	5,657	9,391	82,637	15,224	498,830

[1] Federal Power Commission.
[2] Bureau of the Census, U.S. Department of Commerce, Ore and Coal Exchange.
[3] Estimates based upon reports collected from a selected list of representative steel and rolling mills.
[4] Estimates based upon reports collected from a selected list of representative manufacturing plants.
[5] Estimates based upon reports collected from a selected list of representative retailers. Includes some coal shipped by truck from mine to final destination.
[6] The total of classes shown approximates total consumption. The calculation of consumption from production, imports, exports, and changes in stocks is not as accurate as the "Total of classes shown" because certain significant items of stocks are not included in yearend stocks. These items are stocks on Lake and Tidewater docks, stocks at other intermediate storage piles between mine and consumer, and coal in transit.

Table 39.—Stocks of bituminous coal and lignite in the hands of commercial consumers and in the retail dealers' yards in the United States

Date	Total stocks (thousand short tons)	Days' supply at current rate of consumption on date of stocktaking						
		Electric power utilities	Manufacturing and mining industries				Retail dealers	Total
			Oven coke plants	Steel and rolling mills	Cement mills	Other manufacturing and mining industries		
1967:								
Jan. 31	72,951	64	37	17	54	39	3	50
Feb. 28	70,196	61	37	14	45	36	2	47
Mar. 31	71,231	69	37	17	39	38	3	53
Apr. 30	74,696	77	39	19	36	43	6	60
May 31	80,209	84	42	20	37	46	9	65
June 30	85,234	83	46	26	49	51	16	68
July 31	80,621	85	37	25	53	54	15	68
Aug. 31	86,726	88	39	28	58	50	8	69
Sept. 30	90,707	97	40	25	51	52	5	73
Oct. 31	94,467	98	43	22	57	49	4	73
Nov. 30	95,001	92	42	18	49	44	3	68
Dec. 31	93,128	88	42	18	58	42	3	66
1968:								
Jan. 31	86,325	75	41	17	54	36	2	57
Feb. 29	82,356	70	37	20	61	36	1	54
Mar. 31	82,724	77	40	22	44	40	1	59
Apr. 30	87,773	88	45	24	42	46	4	68
May 31	92,171	94	46	23	41	49	8	73
June 30	93,487	89	45	27	49	55	11	72
July 31	89,404	82	41	33	54	57	12	68
Aug. 31	91,492	79	45	49	58	60	10	68
Sept. 30	96,220	93	51	55	58	62	7	77
Oct. 31	91,966	90	45	40	62	52	5	72
Nov. 30	90,518	83	43	30	57	42	4	65
Dec. 31	85,525	71	45	20	47	38	3	58

Table 40.—Distribution of bituminous coal and lignite, in 1968, by method of movement and consumer use

(Thousand short tons)

Shipments	Electric utilities	Coke and gas plants	Retail dealers	All others	Railroad fuel	Used at mines and sales to employees	Canadian Great Lakes commercial docks [3]	U.S. Great Lakes dock storage [3]	U.S. tidewater dock storage [3]	Overseas exports [4]	Net change in mine inventory	Total
Total shipments to all destinations in the United States, Canada, and Mexico, by all methods of movements and consumer use, and overseas exports	297,350	96,525	17,676	96,978	1,006	1,496	451	−239	−5	33,998	83	545,319
Shipments to all destinations in the United States, Canada, and Mexico by specific method of movement and consumer use:												
Method of movement:												
All-rail	153,229	50,034	9,963	59,809	------	---------	-------	------	------	------	------	273,035
River and ex-river	67,117	26,924	1,003	6,570	------	---------	-------	------	------	------	------	101,614
Great Lakes [1]	20,785	13,084	3,616	11,361	------	---------	-------	------	------	------	------	48,846
Tidewater [2]	13,000	5,286	6	456	------	---------	-------	------	------	------	------	18,748
Truck	25,733	1,189	3,088	18,782	------	---------	-------	------	------	------	------	48,792
Tramway, conveyor, and private railroad	17,486	8	------	------	------	---------	-------	------	------	------	------	17,494
Method of movement and/or consumer uses unknown	-------	------	------	------	1,006	1,496	451	−239	−5	33,998	83	36,790
Total	297,350	96,525	17,676	96,978	1,006	1,496	451	−239	−5	33,998	83	545,319

---

[1] Excludes shipments to Canadian Great Lakes commercial docks and U.S. dock storage for which consumer uses are not available; however, includes vessel fuel, the destinations of which are not available.

[2] Excludes overseas exports and U.S. tidewater dock storage for which consumer uses are not available; however, includes bunker fuel, the destinations of which are not available.

[3] Consumer use unknown.

[4] Excludes Canada; consumer use unknown.

Table 41.—Distribution of bituminous coal and lignite, in 1968, by district of origin and consumer use

(Thousand short tons)

District of origin [1]	Electric utilities	Coke and gas plants	Retail dealers	All others	Railroad fuel	Used at mines and sales to employees
1	28,444	3,767	515	7,976	155	260
2	8,687	22,950	525	6,910	2	24
3 and 6	36,168	6,505	452	7,714	40	21
4	35,264	----------	1,478	12,447	137	31
7	1,920	16,604	1,450	2,236	138	616
8	59,562	32,827	8,215	30,668	218	418
9	40,226	230	1,318	4,713	48	1
10	45,559	2,309	1,752	13,951	127	46
11	12,674	----------	372	5,594	66	8
12	666	----------	----------	124	----------	----------
13	9,932	5,723	153	1,302	----------	2
14	----------	418	----------	74	----------	----------
15 [2]	4,525	160	72	336	----------	----------
16	589	----------	40	52	----------	2
17	2,081	3,227	333	389	----------	2
18	2,751	----------	4	37	----------	----------
19	3,024	31	107	696	28	1
20	1,003	1,779	590	537	4	38
21	3,627	----------	249	523	38	22
22 and 23	648	----------	51	699	5	4
Total	297,350	96,525	17,676	96,978	1,006	1,496

District of origin [1]	Canadian Great Lakes commercial docks [3]	U.S. Great Lakes dock storage [3]	U.S. tidewater dock storage [3]	Overseas exports [4]	Net change in mine inventory	Total
1	23	—2	----------	1,407	—3	42,542
2	51	—17	----------	----------	—46	39,086
3 and 6	127	71	3	847	—138	51,810
4	74	—170	----------	----------	14	49,275
7	3	47	—7	15,180	73	38,260
8	173	—86	—1	16,540	—96	148,438
9	----------	—16	----------	----------	123	46,643
10	----------	—66	----------	----------	53	63,731
11	----------	----------	----------	----------	—41	18,673
12	----------	----------	----------	----------	----------	790
13	----------	----------	----------	----------	148	17,260
14	----------	----------	----------	16	----------	503
15 [2]	----------	----------	----------	----------	—6	5,087
16	----------	----------	----------	----------	—4	679
17	----------	----------	----------	----------	—8	6,024
18	----------	----------	----------	----------	31	2,823
19	----------	----------	----------	----------	—8	3,879
20	----------	----------	----------	8	—3	3,956
21	----------	----------	----------	----------	—6	4,453
22 and 23	----------	----------	----------	----------	----------	1,407
Total	451	—239	—5	33,998	83	545,319

---

[1] Producing districts are defined in: Bureau of Mines. Bituminous Coal and Lignite Distribution Calendar Year 1968. Mineral Industry Survey, March 1969, 39 pp.

[2] Excludes Texas.

[3] Consumer use unknown.

[4] Excludes Canada; consumer use unknown.

Table 42.—Distribution of bituminous coal and lignite, in 1968, by destination and consumer use

(Thousand short tons)

Destination	Total	Electric utilities	Coke and gas plants	Retail dealers	All others [1]
New England:					
Massachusetts	2,872	2,421	--------	114	337
Connecticut	3,013	2,508	158	1	346
Maine, New Hampshire, Vermont, Rhode Island	1,071	908	--------	22	141
Middle Atlantic:					
New York	24,562	12,573	5,108	153	6,728
New Jersey	6,837	5,477	475	7	878
Pennsylvania	59,890	23,551	26,393	699	9,247
East North Central:					
Ohio	59,912	31,467	11,463	2,033	14,949
Indiana	40,245	21,506	11,538	998	6,203
Illinois	43,465	28,221	3,069	3,312	8,863
Michigan	36,787	20,832	4,914	1,474	9,567
Wisconsin	15,075	8,323	339	1,995	4,418
West North Central:					
Minnesota	7,332	5,024	390	795	1,123
Iowa	5,477	3,426	--------	263	1,788
Missouri	9,400	7,094	225	149	1,932
North Dakota and South Dakota	3,781	3,128	--------	312	341
Nebraska and Kansas	1,360	1,095	--------	51	214
South Atlantic:					
Delaware and Maryland	14,777	8,596	5,045	90	1,046
District of Columbia	[2] 887	673	--------	83	[2] 131
Virginia	14,526	9,062	4	720	4,740
West Virginia	24,564	13,710	4,924	425	5,505
North Carolina	16,912	13,958	--------	619	2,335
South Carolina	4,695	3,261	--------	275	1,159
Georgia and Florida	12,052	11,274	--------	205	573
East South Central:					
Kentucky	18,811	14,094	1,831	560	2,326
Tennessee	16,833	13,213	184	584	2,852
Alabama and Mississippi	24,843	15,294	7,548	105	1,896
West South Central: Arkansas, Louisiana, Oklahoma, Texas	976	--------	848	13	115
Mountain:					
Colorado	4,967	3,021	1,129	316	501
Utah	2,836	487	1,877	134	338
Montana and Idaho	1,042	475	--------	351	216
Wyoming	2,702	2,438	--------	30	234
New Mexico	2,392	2,372	--------	4	16
Arizona and Nevada	929	895	--------	18	16
Pacific:					
Washington and Oregon	449	--------	--------	143	306
California	2,097	--------	2,072	11	14
Alaska	804	132	--------	37	635
Canada [3]	16,265	5,661	6,698	516	3,390
Mexico	74	--------	--------	--------	74
Destinations not revealable	2,138	1,180	293	59	606
Destinations and/or consumer uses not available:					
Great Lakes movement:					
Canadian commercial docks	451	--------	--------	--------	--------
Vessel fuel	879	--------	--------	--------	--------
U.S. dock storage	−239	--------	--------	--------	--------
Tidewater movement:					
Overseas exports (except Canada)	33,998	--------	--------	--------	--------
Bunker fuel	--------	--------	--------	--------	--------
U.S. dock storage	−5	--------	--------	--------	--------
Railroad fuel:					
U.S. companies	976	--------	--------	--------	--------
Canadian companies	30	--------	--------	--------	--------
Coal used at mines and sales to employees	1,496	--------	--------	--------	--------
Net change in mine inventory	83	--------	--------	--------	--------
Total	545,319	--------	--------	--------	--------

[1] Excludes vessel fuel and bunker fuel, the destinations of which are not available.
[2] A considerable block of tonnage is included under "Destinations not revealable."
[3] Excludes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

Table 43.—Total bituminous coal and lignite shipments and percent of grand total shipments, by geographic division and State of destination

Geographic division and State of destination	Thousand short tons 1964	1965	1966	1967	1968	Percent of total 1964	1965	1966	1967	1968
Total	485,465	512,525	532,366	552,647	545,319	100.0	100.0	100.0	100.0	100.0
New England	10,007	10,640	10,877	9,741	6,956	2.0	2.1	2.0	1.8	1.3
Massachusetts	4,160	4,681	4,415	4,022	2,872	.8	.9	.8	.7	.5
Connecticut	4,767	4,870	5,434	4,793	3,013	1.0	1.0	1.0	.9	.6
Maine, New Hampshire, Vermont, Rhode Island	1,080	1,089	1,028	926	1,071	.2	.2	.2	.2	.2
Middle Atlantic	90,150	95,721	93,913	96,362	91,289	18.6	18.7	17.6	17.4	16.7
New York	25,932	27,025	25,314	27,300	24,562	5.3	5.3	4.8	4.9	4.5
New Jersey	7,526	9,000	8,692	7,865	6,837	1.6	1.8	1.6	1.4	1.2
Pennsylvania	56,692	59,696	59,907	61,197	59,890	11.7	11.6	11.2	11.1	11.0
East North Central	173,307	182,072	192,251	196,417	195,484	35.7	35.5	36.1	35.5	35.8
Ohio	51,092	52,756	57,622	58,726	59,912	10.5	10.3	10.8	10.6	11.0
Indiana	35,885	36,885	38,424	40,441	40,245	7.4	7.2	7.2	7.3	7.4
Illinois	41,466	44,356	46,382	46,710	43,465	8.5	8.6	8.7	8.5	8.0
Michigan	30,936	33,411	34,770	34,959	36,787	6.4	6.5	6.6	6.3	6.7
Wisconsin	13,928	14,664	15,053	15,581	15,075	2.9	2.9	2.8	2.8	2.7
West North Central	23,918	24,978	25,977	26,761	27,350	4.9	4.9	4.9	4.8	5.0
Minnesota	7,077	7,406	7,680	7,142	7,332	1.4	1.5	1.4	1.3	1.3
Iowa	4,849	5,508	5,440	5,549	5,477	1.0	1.1	1.0	1.0	1.0
Missouri	8,154	8,243	8,494	9,389	9,400	1.7	1.6	1.6	1.7	1.7
North Dakota and South Dakota	2,191	2,211	2,996	3,427	3,781	.5	.4	.6	.6	.7
Nebraska and Kansas	1,647	1,610	1,367	1,254	1,360	.3	.3	.3	.2	.3
South Atlantic	67,866	72,052	80,491	88,499	88,413	14.0	14.1	15.1	16.0	16.2
Delaware and Maryland	12,317	13,288	14,082	14,954	14,777	2.6	2.6	2.6	2.7	2.7
District of Columbia	[1] 638	[1] 541	[1] 897	[1] 886	[1] 887	[1] .1	[1] .1	[1] .2	[1] .1	[1] .2
Virginia	13,787	13,887	14,279	14,854	14,526	2.8	2.7	2.7	2.7	2.7
West Virginia	18,205	19,337	20,159	23,244	24,564	3.8	3.8	3.8	4.2	4.5
North Carolina	11,595	12,376	15,352	17,515	16,912	2.4	2.4	2.9	3.2	3.1
South Carolina	4,401	4,301	5,118	5,554	4,695	.9	.9	.9	1.0	.8
Georgia and Florida	6,923	8,322	10,604	11,492	12,052	1.4	1.6	2.0	2.1	2.2
East South Central	49,849	52,103	54,929	61,312	60,487	10.3	10.2	10.3	11.1	11.1
Kentucky	16,148	16,834	17,644	19,046	18,811	3.3	3.3	3.3	3.4	3.4
Tennessee	14,075	13,896	14,811	18,185	16,833	2.9	2.7	2.8	3.3	3.1
Alabama and Mississippi	19,626	21,373	22,474	24,081	24,843	4.1	4.2	4.2	4.4	4.6
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,099	1,166	1,084	955	976	.2	.2	.2	.2	.2
Mountain	12,455	13,866	14,098	14,261	14,868	2.6	2.7	2.7	2.6	2.7
Colorado	3,877	4,500	4,705	4,720	4,967	.8	.9	.9	.9	.9
Utah	2,706	2,868	2,974	2,853	2,836	.6	.6	.6	.5	.5
Montana and Idaho	1,190	1,075	995	968	1,042	.3	.2	.2	.2	.2
Wyoming	1,936	2,196	2,601	2,494	2,702	.4	.4	.5	.4	.5
New Mexico	2,169	2,505	2,084	2,526	2,892	.4	.5	.4	.5	.4
Arizona and Nevada	577	722	739	700	929	.1	.1	.1	.1	.2
Pacific	2,789	3,176	2,575	2,592	2,546	.6	.6	.5	.5	.5
Washington and Oregon	774	798	687	541	449	.2	.2	.1	.1	.1
California	2,015	2,378	1,888	2,051	2,097	.4	.4	.4	.4	.4

Alaska	842	789	858	952	804	.2	.1	.2	.2	.1
Canada [3]	14,180	15,634	15,807	15,257	16,746	2.9	3.0	3.0	2.8	3.1
Mexico	54	60	54	62	74	(2)	(2)	(2)	(2)	(2)
Destinations not revealable	1,496	1,385	1,211	994	2,138	.3	.3	.2	.2	.4
U.S. railroad fuel	1,321	1,241	1,260	1,146	976	.3	.2	.2	.2	.2
U.S. Great Lakes dock storage	—327	—252	—6	—62	—239	—.1	(2)	(2)	(2)	(2)
U.S. tidewater dock storage	9	10	4	---------	—5	(2)	(2)	(2)	-------	(2)
Vessel fuel	1,106	1,004	1,054	878	879	.2	.2	.2	.1	.2
Bunker fuel	17	13	13	5	---------	(2)	(2)	(2)	(2)	-------
Overseas exports	33,733	34,746	33,527	34,174	33,998	7.0	6.8	6.3	6.2	6.2
Coal used at mines and sales to employees	1,956	1,969	2,098	1,678	1,496	.4	.4	.4	.3	.3
Net change in mine inventory	—362	152	291	663	83	—.1	(2)	.1	.1	(2)

---

[1] A considerable block of tonnage is included under "Destinations not revealable."

[2] Less than 0.1 percent.

[3] Includes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

Table 44.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957=100 (except where noted)				
		1964	1965	1966	1967	1968
Total	493,895	98.3	103.8	107.8	111.9	110.4
Electric utilities	160,754	142.7	155.1	169.0	184.2	185.0
Coke and gas plants	112,901	84.7	89.0	89.1	88.4	85.5
Retail dealers	39,230	58.4	58.2	52.7	47.9	45.1
All others (includes vessel and bunker fuel)	108,711	92.2	92.8	93.7	91.9	89.2
Railroad fuel (U.S. and Canada)	9,581	15.0	13.7	13.7	12.8	10.5
Canadian Great Lakes commercial docks (consumer use not available)	2,785	30.0	38.6	15.4	13.2	16.2
U.S. Great Lakes dock storage (consumer use not available)[1]	NA	—207.6	—182.9	—102.0	—120.4	—178.6
U.S. tidewater dock storage (consumer use not available)[2]	NA	34.6	38.5	15.4	-------	—119.2
Coal used at mines and sales to employees	3,125	62.6	63.0	67.1	53.7	47.9
Net change in mine inventory	1,142	—131.7	13.3	25.5	58.1	7.3
Overseas exports (excludes Canada—consumer use not available)	55,666	60.6	62.4	60.2	61.4	61.1
New England	11,909	84.0	89.3	91.3	81.8	58.4
Electric utilities	6,012	136.4	149.8	157.3	135.8	97.1
Coke and gas plants	1,845	35.4	35.1	33.8	35.9	11.7
Retail dealers	1,279	19.2	16.7	14.5	12.8	10.7
All others	3,273	33.2	29.1	23.8	28.3	25.2
Massachusetts	5,354	77.7	87.4	82.5	75.1	53.6
Electric utilities	2,575	133.0	159.5	156.1	132.7	94.0
Coke and gas plants	751	.0	.0	.0	.0	.0
Retail dealers	755	21.2	16.0	14.4	14.6	15.1
All others	1,273	45.1	35.7	22.5	38.8	26.5
Connecticut	4,105	116.1	118.6	132.4	116.8	73.4
Electric utilities	2,567	155.2	159.8	182.1	157.0	97.7
Coke and gas plants	594	80.1	79.5	76.4	81.3	26.6
Retail dealers	139	18.7	9.4	8.6	8.6	.7
All others	805	34.8	35.3	36.4	33.3	43.0
Maine, New Hampshire, Vermont, Rhode Island	2,450	44.1	44.4	42.0	37.8	43.7
Electric utilities	870	90.7	91.5	87.8	82.6	104.4
Retail dealers	385	15.6	20.5	16.9	10.9	5.7
All others	1,195	19.3	17.9	16.7	13.8	11.8
Middle Atlantic	92,596	97.4	103.4	101.4	104.1	98.6
Electric utilities	31,662	121.4	134.0	132.8	140.0	131.4
Coke and gas plants	38,448	83.5	90.1	87.1	88.0	83.2
Retail dealers	2,498	45.8	53.0	43.8	38.5	34.4
All others	19,988	92.3	86.8	86.5	86.2	84.3
New York	26,753	96.9	101.0	94.6	102.0	91.8
Electric utilities	12,335	104.4	112.2	101.2	116.2	101.9
Coke and gas plants	5,693	100.5	109.7	103.3	105.0	89.7
Retail dealers	769	39.9	47.9	33.8	21.5	19.9
All others	7,956	88.2	82.7	84.0	85.8	84.6
New Jersey	7,814	96.3	115.2	111.2	100.7	87.5
Electric utilities	4,284	133.7	168.2	166.9	149.5	127.8
Coke and gas plants	1,249	28.0	35.0	40.9	39.2	38.0
Retail dealers	130	20.0	31.5	12.8	11.5	5.4
All others	2,151	66.1	61.3	47.1	44.5	40.8
Pennsylvania	58,029	97.7	102.9	103.2	105.5	103.2
Electric utilities	15,043	131.9	142.1	148.9	156.9	156.6
Coke and gas plants	31,506	82.6	88.7	86.0	86.9	83.8
Retail dealers	1,599	50.0	57.2	51.1	48.8	43.7
All others	9,881	101.3	95.6	97.0	95.7	93.6
East North Central	[3] 170,697	101.5	106.7	112.6	115.1	114.5
Electric utilities	66,436	128.1	138.2	151.7	162.8	166.1
Coke and gas plants	38,757	80.9	83.1	86.6	83.8	80.8
Retail dealers	21,321	58.7	59.8	54.9	50.3	46.0
All others	[3] 44,183	100.3	102.5	104.5	102.0	99.6
Ohio	55,612	91.9	94.9	103.6	105.6	10.77
Electric utilities	20,193	117.7	122.8	140.3	149.0	155.8
Coke and gas plants	15,661	66.8	69.1	78.1	74.1	73.2
Retail dealers	5,077	49.3	50.6	45.9	43.2	40.0
All others	14,681	97.8	99.1	100.4	101.1	101.8
Indiana	34,938	102.7	105.6	110.0	115.8	115.2
Electric utilities	12,853	132.4	139.7	144.7	160.5	167.3
Coke and gas plants	13,736	86.3	86.8	89.2	89.7	84.0
Retail dealers	2,796	48.7	44.6	41.6	38.3	35.7
All others	5,553	101.7	103.7	115.5	115.7	111.7

See footnotes at end of table.

Table 44.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1964	1965	1966	1967	1968
Illinois	[3] 42,718	97.1	103.8	108.6	109.3	101.7
Electric utilities	18,584	123.7	135.5	149.6	158.7	151.9
Coke and gas plants	3,925	84.3	91.9	92.4	87.9	78.2
Retail dealers	8,623	55.8	52.9	49.4	47.2	38.4
All others	[3] 11,586	89.4	95.0	92.2	83.6	76.5
Michigan	26,255	117.8	127.3	132.4	133.2	140.1
Electric utilities	9,839	149.3	172.4	187.7	199.3	211.7
Coke and gas plants	4,877	108.9	109.5	102.8	94.1	100.8
Retail dealers	3,368	52.6	60.3	54.4	44.1	43.8
All others	8,171	112.2	111.1	115.8	113.5	117.1
Wisconsin	11,174	124.6	131.2	134.7	139.4	134.9
Electric utilities	4,967	134.1	139.3	152.7	168.3	167.6
Coke and gas plants	558	74.7	92.8	83.0	89.1	60.8
Retail dealers	1,457	142.5	160.1	145.2	131.4	136.9
All others	4,192	113.8	116.7	116.6	114.8	105.4
West North Central	[3] 20,824	114.9	119.9	124.7	128.5	131.3
Electric utilities	8,278	166.9	178.3	198.8	214.9	238.8
Coke and gas plants	1,518	78.3	75.0	76.5	75.6	40.5
Retail dealers	4,079	53.4	52.8	46.3	40.3	38.5
All others	[3] 6,949	96.9	99.6	93.2	88.9	77.7
Minnesota	5,332	132.7	138.9	144.0	133.9	137.5
Electric utilities	1,810	212.7	223.4	255.5	228.6	277.6
Coke and gas plants	1,206	85.5	78.9	78.9	77.0	32.3
Retail dealers	553	105.1	128.9	128.8	123.9	143.8
All others	1,763	91.7	96.3	79.0	78.9	63.7
Iowa	[3] 4,878	99.4	112.9	111.5	113.8	112.3
Electric utilities	1,846	125.6	149.7	157.9	174.8	185.6
Retail dealers	1,254	43.7	45.1	35.2	28.3	21.0
All others	[3] 1,778	111.5	122.6	117.2	110.6	100.6
Missouri	6,862	118.1	120.1	123.8	136.8	137.0
Electric utilities	2,605	208.0	212.7	228.3	266.6	272.3
Coke and gas plants	312	50.6	59.6	67.0	70.2	72.1
Retail dealers	1,495	30.6	23.3	18.5	12.6	10.0
All others	2,450	86.6	88.5	84.2	83.1	78.9
North Dakota and South Dakota	2,416	90.7	91.5	124.0	141.8	156.5
Electric utilities	1,378	94.6	98.5	157.7	190.3	227.0
Retail dealers	517	93.0	84.5	77.0	71.0	60.3
All others	521	77.9	80.0	81.6	84.1	65.5
Nebraska and Kansas	1,336	123.3	120.5	102.3	93.9	101.8
Electric utilities	639	144.8	165.6	124.6	134.7	171.4
Retail dealers	260	43.1	34.6	23.1	17.7	19.6
All others	437	139.6	105.7	116.9	79.4	49.0
South Atlantic	52,560	129.1	137.1	153.1	168.4	168.2
Electric utilities	22,251	174.0	192.5	231.5	267.7	272.1
Coke and gas plants	11,321	90.5	95.5	92.0	91.4	88.1
Retail dealers	4,765	66.3	55.5	52.6	50.6	50.7
All others	14,223	110.7	110.8	112.9	113.7	108.9
Delaware and Maryland	10,358	118.9	128.3	136.0	144.4	142.7
Electric utilities	3,000	192.5	233.1	270.3	290.4	286.5
Coke and gas plants	5,414	92.8	94.5	91.7	99.6	93.2
Retail dealers	420	84.3	53.3	26.4	22.1	21.4
All others	1,524	76.4	62.6	58.8	49.5	68.6
District of Columbia	1,097	[4] 58.2	[4] 49.3	[4] 81.8	[4] 80.8	[4] 80.9
Electric utilities	609	61.4	49.4	81.6	89.7	110.5
Retail dealers	188	72.3	63.8	53.7	47.3	44.1
All others	300	[4] 42.7	[4] 40.0	[4] 99.7	[4] 83.7	[4] 43.7
Virginia	10,553	130.6	131.6	135.3	140.8	137.6
Electric utilities	4,435	176.4	170.8	185.9	200.6	204.3
Coke and gas plants	165	76.4	161.2	157.6	43.6	2.4
Retail dealers	1,756	61.4	51.8	47.3	42.9	41.0
All others	4,197	113.4	122.4	117.8	122.3	112.9
West Virginia	15,771	115.4	122.6	127.8	147.4	155.8
Electric utilities	6,290	121.3	138.3	152.5	201.4	218.0
Coke and gas plants	5,742	88.7	94.6	90.4	85.1	85.8
Retail dealers	302	85.4	92.4	101.7	129.8	140.7
All others	3,437	152.0	143.3	147.4	154.1	160.2
North Carolina	8,716	133.0	142.0	176.1	201.0	194.0
Electric utilities	4,953	171.4	189.1	246.8	289.7	281.8
Retail dealers	1,248	59.8	50.2	51.2	51.0	49.6
All others	2,515	93.9	94.7	98.9	100.6	92.8

See footnotes at end of table.

Table 44.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957=100 (except where noted)				
		1964	1965	1966	1967	1968
South Carolina	3,050	144.3	141.0	167.8	182.1	153.9
Electric utilities	856	303.9	278.9	378.5	452.9	381.0
Retail dealers	321	94.1	82.2	92.2	83.8	85.7
All others	1,873	80.0	88.1	84.5	75.2	61.9
Georgia and Florida	3,015	229.6	276.0	351.7	381.2	399.7
Electric utilities	2,108	286.1	356.4	455.3	499.0	534.8
Retail dealers	530	53.8	42.1	42.1	33.4	38.7
All others	377	160.7	155.4	208.0	211.1	152.0
East South Central	43,283	115.2	120.4	126.9	141.7	139.7
Electric utilities	28,572	145.3	149.5	159.8	184.2	180.7
Coke and gas plants	10,380	81.7	88.6	90.0	97.0	92.1
Retail dealers	2,494	62.1	56.0	50.7	46.1	50.1
All others	6,837	81.5	91.5	97.3	97.3	103.5
Kentucky	11,167	144.6	150.7	158.0	170.6	168.5
Electric utilities	6,758	165.4	176.6	187.6	208.4	208.6
Coke and gas plants	1,683	110.9	114.0	104.0	116.3	108.8
Retail dealers	834	77.3	62.4	66.2	59.7	67.1
All others	1,892	129.8	129.9	140.0	132.3	122.9
Tennessee	15,104	93.2	92.0	98.1	120.4	111.4
Electric utilities	9,876	112.1	107.6	115.7	149.6	138.8
Coke and gas plants	258	59.3	70.2	69.8	67.4	71.3
Retail dealers	1,206	61.2	63.2	50.4	46.0	48.4
All others	3,764	56.2	61.9	69.0	71.2	75.8
Alabama and Mississippi	17,012	115.4	125.6	132.1	141.6	146.0
Electric utilities	6,938	173.0	182.9	195.3	209.7	220.4
Coke and gas plants	8,439	76.5	84.1	87.8	94.0	89.4
Retail dealers	454	36.6	25.1	22.9	21.4	23.1
All others	1,181	84.8	124.4	119.5	127.2	160.5
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,868	58.8	62.4	58.0	51.1	52.2
Electric utilities [5]	65	75.0	.0	.0	.0	.0
Coke and gas plants	1,050	82.5	94.9	90.3	78.3	80.8
Retail dealers	161	19.3	17.4	17.4	14.3	8.1
All others	592	31.1	24.0	18.2	18.6	19.4
Mountain	8,779	141.9	157.9	160.6	162.4	169.4
Electric utilities	1,437	485.0	572.5	605.0	639.0	674.2
Coke and gas plants	3,772	74.1	85.3	83.9	77.5	79.7
Retail dealers	1,350	86.3	85.0	77.3	71.6	63.2
All others	2,220	68.7	57.3	53.9	53.6	59.5
Colorado	3,264	118.8	137.9	144.1	144.6	152.2
Electric utilities	687	281.2	357.5	401.5	424.9	439.8
Coke and gas plants	1,324	83.5	99.8	93.1	79.8	85.3
Retail dealers	326	102.1	113.2	105.2	88.7	96.9
All others	927	54.7	38.1	40.1	49.1	54.0
Utah	3,748	72.2	76.5	79.3	76.1	75.7
Electric utilities	367	111.7	102.7	132.4	130.5	132.7
Coke and gas plants	2,448	69.0	77.5	78.9	76.2	76.7
Retail dealers	334	69.5	62.6	55.7	57.8	40.1
All others	599	62.4	64.3	61.9	52.8	56.4
Montana and Idaho	923	128.9	116.5	107.8	104.9	112.9
Electric utilities [6]	1	164.2	165.9	181.6	183.3	265.4
Retail dealers	593	80.6	72.8	63.6	72.0	59.2
All others	329	127.1	105.2	89.1	64.7	65.7
Wyoming	607	318.9	361.8	428.5	410.9	445.1
Electric utilities	340	518.2	597.4	716.8	673.8	717.1
Retail dealers	61	82.0	82.0	63.9	45.9	49.2
All others	206	60.2	55.8	60.7	85.0	113.6
New Mexico [7]	92	191.6	221.3	184.1	223.1	211.3
Electric utilities [7]	37	195.0	227.8	190.2	230.8	218.6
Retail dealers	12	150.0	108.3	58.3	41.7	33.3
All others	43	81.4	46.5	30.2	39.5	37.2
Arizona and Nevada	145	397.9	497.9	509.7	482.8	640.7
Electric utilities [8]	5	136.1	177.3	186.3	197.3	267.2
Retail dealers	24	225.0	308.3	383.3	104.2	75.0
All others	116	57.8	46.6	19.8	12.1	13.8
Pacific	3,142	88.8	101.1	82.0	82.5	81.0
Electric utilities	4	.0	.0	.0	.0	.0
Coke and gas plants	1,708	115.7	137.1	107.7	118.1	121.3
Retail dealers	377	75.9	87.8	71.1	54.4	40.8
All others	1,053	50.0	47.9	44.4	35.1	30.4

See footnotes at end of table.

Table 44.—The changing levels of bituminous coal and lignite markets—indexes of physical volumes shipped to markets, by geographic division, State of destination, and consumer use—Continued

Geographic division, State of destination, and consumer use	1957 (thousand short tons)	Index 1957 = 100 (except where noted)				
		1964	1965	1966	1967	1968
Washington and Oregon	1,324	58.5	60.3	51.9	40.9	33.9
Electric utilities	3	.0	.0	.0	.0	.0
Retail dealers	367	75.7	86.6	69.2	52.0	39.0
All others	954	52.0	50.8	45.4	36.7	32.1
California	1,818	110.8	130.8	108.9	112.8	115.8
Electric utilities	1	.0	.0	.0	.0	.0
Coke and gas plants	1,708	115.7	137.1	107.7	118.1	121.8
Retail dealers	10	80.0	130.0	140.0	140.0	110.0
All others	99	31.3	24.2	35.4	20.2	14.1
Alaska	829	101.6	95.2	103.5	114.8	97.0
Electric utilities	470	75.3	92.3	43.4	28.7	28.1
Retail dealers	49	89.8	81.6	89.8	87.8	75.5
All others	310	143.2	101.6	196.8	249.7	204.8
Canada [9]	17,878	79.3	87.4	88.4	85.3	93.7
Electric utilities	567	560.0	705.6	794.7	869.8	998.4
Coke and gas plants	4,602	120.5	115.0	127.2	119.8	145.5
Retail dealers	857	64.4	83.8	65.1	51.6	60.2
All others	7,183	55.0	62.2	61.4	55.3	47.2
Canadian Great Lakes commerical docks (consumer use not available)	2,785	30.0	38.6	15.4	13.2	16.2
Canadian railroad companies	1,884	6.2	4.0	2.5	1.8	1.6
Mexico [10]	NA	94.7	105.3	94.7	108.8	129.8
All others [10]	NA	94.7	105.3	94.7	108.8	129.8
Destinations not revealable [11]	-------	108.4	100.4	87.8	72.0	154.9
Electric utilities [11]	-------	61.8	105.0	62.0	98.0	287.4
Coke and gas plants [11]	-------	161.5	54.8	83.4	42.8	78.3
Retail dealers [11]	-------	35.4	89.8	80.8	49.5	59.6
All others [11]	-------	134.1	138.8	124.6	72.7	147.8
Destinations not available:						
Great Lakes vessel fuel [12]	1,859	59.5	54.0	56.7	47.2	47.3
Tidewater bunker fuel [12]	41	41.5	31.7	31.7	12.2	.0
Railroad fuel, United States companies [13]	7,697	17.2	16.1	16.4	14.9	12.7

NA Not available.

[1] For Great Lakes dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 304,000 tons.

[2] For tidewater dock storage the annual base period is 1959 = 100. The 1959 annual tonnage was 26,000 tons

[3] District 15 shipments to Illinois included with Iowa.

[4] A considerable block of tonnage is included under "Destinations not revealable."

[5] For electric utilities in Arkansas, Louisiana, Oklahoma, and Texas the annual base period is 1963 = 100. The 1963 tonnage shipped to electric utilities was 24,000 tons.

[6] For electric utilities in Montana and Idaho the annual base period is 1959 = 100. The 1959 tonnage shipped to electric utilities was 179,000 tons.

[7] For total shipments and electric utilities to New Mexico the annual base period is 1963 = 100. Total shipments to New Mexico were 1,132,000 tons and for electric utilities 1,085,000 tons.

[8] For electric utilities in Arizona and Nevada the annual base period is 1962 = 100. The 1962 annual tonnage

[9] Includes shipments to Canadian Great Lakes commercial docks and Canadian railroad companies.

[10] Since tonnages for Mexico were first published in 1960, yearly indexes are based on 1960 = 100. 1960 tons were total 57,000, all others 57,000.

[11] Since "Destinations not revealable" were first published during 1960, the calendar year indexes are based on 1960 = 100. These figures are as follows: Calendar year 1960 total not revealable 1,380,000, electric utilities 497,000, coke and gas plants 374,000, retail dealers 99,000, all others 410,000.

[12] Included in summary at beginning of table in "All others."

[13] Included in summary at beginning of table in "Railroad fuel."

Table 45.—Average value per ton, f.o.b. mines, of bituminous coal and lignite produced in the United States, by States

State	1967				1968			
	Underground	Strip	Auger	Total	Underground	Strip	Auger	Total
Alabama	$8.63	$4.85	$8.16	$7.15	$8.78	$4.79	$8.16	$7.04
Alaska	------	7.89	------	7.89	------	6.00	------	6.00
Arizona	5.35	------	------	5.35	------	------	------	------
Arkansas	7.62	7.54	------	7.56	7.82	7.33	------	7.47
Colorado	5.50	3.36	3.90	4.77	5.48	3.43	------	4.82
Illinois	3.96	3.83	------	3.88	4.14	3.92	3.25	4.01
Indiana	4.31	3.87	------	3.91	4.38	3.81	------	3.88
Iowa	3.63	3.67	------	3.66	3.83	3.71	------	3.75
Kansas	------	4.66	------	4.66	------	5.15	------	5.15
Kentucky	4.48	3.26	3.05	3.96	4.30	3.35	3.06	3.91
Maryland	4.45	3.12	2.36	3.48	4.25	3.64	2.00	3.67
Missouri	5.00	4.21	------	4.21	------	4.20	------	4.20
Montana:								
Bituminous	8.27	7.50	------	8.08	8.53	1.86	------	3.12
Lignite	4.50	1.96	------	1.97	------	1.89	------	1.89
Total	8.17	1.98	------	2.68	8.53	1.88	------	2.84
New Mexico	8.20	2.56	------	3.65	8.38	2.66	------	3.94
North Dakota (lignite)	------	1.92	------	1.92	------	1.78	------	1.78
Ohio	4.39	3.59	3.38	3.84	4.46	3.72	3.39	3.96
Oklahoma	8.00	5.71	7.47	5.72	6.46	5.85	8.16	5.88
Pennsylvania	5.89	3.76	4.08	5.28	5.97	3.84	4.05	5.37
South Dakota (lignite)	------	5.00	------	5.00	------	----	------	------
Tennessee	4.19	3.64	3.30	3.95	3.66	3.61	3.60	3.64
Utah	5.82	------	------	5.82	5.77	------	------	5.77
Virginia	4.92	3.46	3.20	4.66	5.07	3.55	3.48	4.84
Washington	8.85	7.44	------	8.78	9.07	2.91	------	4.63
West Virginia	5.35	4.08	4.25	5.21	5.46	4.31	4.06	5.32
Wyoming	6.21	3.21	------	3.31	6.34	3.06	------	3.16
Total	5.18	3.68	3.59	4.62	5.22	3.75	3.53	4.67

Table 46.—Production and average value per ton, f.o.b. mines, of bituminous coal and lignite sold in open market and not sold in open market, by States

(Thousand short tons)

State	Production			Average value per ton, f.o.b. mines		
	Sold in open market	Not sold in open market	Total [1]	Sold in open market	Not sold in open market	Total
1967						
Alabama	8,430	7,055	15,486	$5.77	$8.80	$7.15
Alaska	925	--------	925	7.89	--------	7.89
Arizona	1	--------	1	5.35	--------	5.35
Arkansas	189	--------	189	7.56	--------	7.56
Colorado	4,006	1,433	5,439	4.20	6.35	4.77
Illinois	65,133	--------	65,133	3.88	--------	3.88
Indiana	18,772	--------	18,772	3.91	--------	3.91
Iowa	883	--------	883	3.66	--------	3.66
Kansas	1,136	--------	1,136	4.66	--------	4.66
Kentucky	94,346	5,947	100,294	3.83	5.94	3.96
Maryland	1,305	--------	1,305	3.48	--------	3.48
Missouri	3,696	--------	3,696	4.21	--------	4.21
Montana:						
Bituminous	42	1	42	8.03	7.61	8.08
Lignite	329	--------	329	1.97	--------	1.97
Total [1]	371	1	371	2.68	7.61	2.68
New Mexico	2,818	645	3,463	2.58	8.34	3.65
North Dakota (lignite)	4,068	88	4,156	1.93	1.35	1.92
Ohio	39,757	6,256	46,014	3.92	3.35	3.84
Oklahoma	823	--------	823	5.72	--------	5.72
Pennsylvania	48,734	30,678	79,412	4.30	6.84	5.28
South Dakota (lignite)	5	--------	5	5.00	--------	5.00
Tennessee	6,832	--------	6,832	3.95	--------	3.95
Utah	3,067	1,108	4,175	5.03	8.00	5.82
Virginia	35,145	1,576	36,721	4.56	6.90	4.66
Washington	59	--------	59	8.78	--------	8.78
West Virginia	133,876	19,873	153,749	5.06	6.22	5.21
Wyoming	1,679	1,908	3,588	3.70	2.97	3.31
Total [1]	476,057	76,569	552,626	4.34	6.42	4.62
1968						
Alabama	9,274	7,166	16,440	$5.55	$8.98	$7.04
Alaska	750	--------	750	6.00	--------	6.00
Arkansas	211	--------	211	7.47	--------	7.47
Colorado	4,110	1,448	5,558	4.28	6.35	4.82
Illinois	62,177	264	62,441	4.01	5.40	4.01
Indiana	18,486	--------	18,486	3.88	--------	3.88
Iowa	876	--------	876	3.75	--------	3.75
Kansas	1,268	--------	1,268	5.15	--------	5.15
Kentucky	94,981	6,175	101,156	3.77	6.03	3.91
Maryland	1,447	--------	1,447	3.67	--------	3.67
Missouri	3,205	--------	3,205	4.20	--------	4.20
Montana:						
Bituminous	188	--------	189	3.12	5.70	3.12
Lignite	330	--------	330	1.89	--------	1.89
Total [1]	518	--------	519	2.34	5.70	2.34
New Mexico	2,684	745	3,429	2.67	8.50	3.94
North Dakota (lignite)	4,373	113	4,487	1.79	1.30	1.78
Ohio	42,078	6,245	48,323	3.96	3.97	3.96
Oklahoma	1,089	--------	1,089	5.88	--------	5.88
Pennsylvania	47,562	28,639	76,200	4.40	6.97	5.37
Tennessee	8,148	--------	8,148	3.64	--------	3.64
Utah	3,188	1,133	4,316	4.93	8.13	5.77
Virginia	36,044	922	36,966	4.79	6.74	4.84
Washington	53	125	178	8.98	2.80	[illegible]
West Virginia	126,702	19,220	145,921	5.17	6.31	5.32
Wyoming	1,905	1,925	3,829	3.73	2.60	[illegible]
Total [1]	471,124	74,121	545,245	4.38	6.55	4.67

[1] Data may not add to totals shown because of independent rounding.

Table 47.—Summary of operations at lignite mines in the United States, in 1967, by States[1]

Item	Montana	North Dakota	South Dakota	Total[2]
UNDERGROUND MINES				
Number of mines	1	----------	----------	1
Production: Shot from solid.....thousand short tons	1	----------	----------	1
Average value per ton	$4.50	----------	----------	$4.50
Average number of men working daily	3	----------	----------	3
Average number of days worked	180	----------	----------	180
Number of man-days worked	1	----------	----------	1
Average tons per man per day	2.18	----------	----------	2.18
STRIP MINES				
Number of mines	2	24	1	27
Production (thousand short tons)	328	4,156	5	4,489
Average value per ton	$1.96	$1.92	$5.00	$1.92
Number of shovels and draglines	3	47	2	52
Average number of men working daily	18	303	5	326
Average number of days worked	239	212	108	212
Number of man-days worked	4	64	1	69
Average tons per man per day	76.33	64.76	9.79	65.06
TOTAL, ALL LIGNITE MINES				
Number of mines	3	24	1	28
Production (thousand short tons):				
Shipped by rail[3]	325	2,623	----------	2,948
Shipped by truck	4	387	5	396
Used at mines[4]	---------	1,146	----------	1,146
Total	329	4,156	5	4,490
Average value per ton	$1.97	$1.92	$5.00	$1.92
Average number of men working daily	21	303	5	329
Average number of days worked	226	212	108	213
Number of man-days worked	5	64	1	70
Average tons per man per day	69.18	64.76	9.79	64.14

[1] Exclusive of Texas (lignite).
[2] Data may not add to totals shown because of independent rounding.
[3] Includes coal loaded at mines directly into railroad cars and hauled by trucks to railroad sidings.
[4] Includes coal used at mine for power and heat, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor or tram.

Table 48.—Summary of operations at lignite mines[1] in the United States, in 1968, by States[2]

Item	Montana	North Dakota	Total[3]
Number of mines	2	22	24
Production (thousand short tons):			
Shipped by rail[4]	329	2,950	3,279
Shipped by truck	1	315	316
Used at mines[5]	-------	1,221	1,221
Total[3]	330	4,487	4,817
Average value per ton	$1.89	$1.78	$1.79
Number of shovels and draglines	3	45	48

[1] All strip.
[2] Exclusive of Texas (lignite).
[3] Data may not add to totals shown because of independent rounding.
[4] Includes coal loaded at mines directly into railroad cars and hauled by trucks to railroad sidings.
[5] Includes coal used at mine for power and heat, used by mine employees, used for all other purposes at mine, and transported from mine to point of use by conveyor or tram.

Table 49.—Exports of bituminous coal, by country groups

(Thousand short tons and thousand dollars)

Country group	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada (including Newfoundland) and Mexico	15,882	$130,296	r 15,370	$128,482	16,822	$143,021
Overseas (all other countries):						
West Indies and Central America	(1)	8	r 2	21	1	11
Bermuda, Greenland, Miquelon and St. Pierre Islands	5	54	6	69	3	30
South America	2,613	25,977	2,562	26,240	2,569	26,401
Europe	22,984	219,563	r 19,362	189,526	15,403	154,991
Asia	7,794	81,756	r 12,220	130,622	15,839	171,525
Africa	9	84	6	55	(1)	1
Oceania	15	161	---------	---------	---------	---------
Total overseas	33,420	327,603	r 34,158	346,533	33,815	352,959
Grand total	49,302	457,899	r 49,528	475,015	50,637	495,980

r Revised.

[1] Less than ½ unit.

Table 50.—Bituminous coal exported from the United States, by countries[1]

(Thousand short tons and thousand dollars)

Country	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	662	$6,633	590	$6,188	441	$4.450
Australia	15	161	--------	--------	--------	--------
Belgium-Luxembourg	1,841	17,643	1,422	13,732	1,052	10,843
Brazil	1,739	17,207	1,735	17,529	1,787	18,227
Canada	15,829	129,646	r 15,308	127,786	16,748	142,156
Chile	156	1,571	193	2,050	306	3,343
France	1,573	15,850	2,131	19,737	1,459	13,787
Germany:						
East	158	1,610	77	868	101	1,171
West	4,894	45,499	4,694	44,414	3,785	36,273
Ireland	355	3,341	267	2,618	168	1,707
Italy	7,806	74,779	r 5,815	59,004	4,254	43,576
Japan	7,791	81,731	r 12,215	130,525	15,822	171,418
Mexico	53	650	62	746	74	865
Miquelon and St. Pierre Islands	5	54	6	69	3	30
Netherlands	3,165	29,656	2,228	21,219	1,491	14,904
Nigeria	6	52	6	55	--------	--------
Norway	220	2,201	246	2,410	305	3,043
Portugal	121	1,124	86	1,031	--------	--------
Rumania	84	796	--------	--------	83	958
Spain	1,194	11,981	1,012	10,381	1,480	15,928
Sweden	951	9,519	813	8,344	761	8,003
Switzerland	24	237	39	411	28	303
Uruguay	54	558	43	466	34	373
Yugoslavia	596	5,810	532	5,358	436	4,504
Other	11	90	8	124	19	128
Total[2]	49,302	457,899	r 49,528	475,015	50,637	495,980

r Revised.

[1] Amounts stated do not include fuel or bunker coal loaded on vessels engaged in foreign trade, which aggregated 214,515 tons ($2,164,414) in 1966, 145,497 tons ($1,490,974) in 1967 and 107,749 tons ($1,097,120) in 1968.

[2] Data may not add to totals shown because of independent rounding.

Table 51.—Bituminous coal exported from the United States, by customs districts

(Thousand short tons and thousand dollars)

Customs district	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Baltimore, Md	2,390	$21,803	1,944	$17,597	2,436	$22,501
Buffalo, N.Y	1,006	7,371	558	4,365	425	3,371
Chicago, Ill	73	517	63	438	29	203
Cleveland, Ohio	13,884	113,357	r 14,061	116,592	15,540	131,031
Detroit, Mich	122	1,268	66	771	92	914
Duluth, Minn	4	47	3	46	3	32
El Paso, Tex	49	620	47	607	44	559
Houston, Tex	(1)	1	(1)	2	--------	---------
Laredo, Tex	3	30	15	138	29	304
Los Angeles, Calif	10	63	(1)	2	8	80
Miami, Fla	r (1)	r (1)	--------	--------	--------	---------
Milwaukee, Wis	-------	--------	--------	--------	10	73
Mobile, Ala	(1)	3	(1)	3	1	7
New Orleans, La	7	61	6	57	31	354
New York City	17	131	(1)	2	85	873
Norfolk, Va	31,473	310,084	32,607	332,780	31,820	334,781
Ogdensburg, N.Y	168	1,672	129	1,314	64	682
Pembina, N. Dak	-------	6	1	8	9	86
Philadelphia, Pa	52	464	(1)	2	--------	---------
Portland, Maine	3	32	--------	--------	1	17
Providence, R.I	4	23	--------	--------	5	44
St. Albans, Vt	35	327	25	264	5	64
San Diego, Calif	(1)	1	(1)	1	(1)	2
San Francisco, Calif	-------	--------	3	26	--------	---------
Savannah, Ga	-------	--------	--------	--------	(1)	2
Seattle, Wash	2	18	--------	--------	--------	---------
Tampa, Fla	-------	--------	(1)	(1)	--------	---------
Total [2]	49,302	457,899	r 49,528	475,015	50,637	495,980

r Revised.

[1] Less than ½ unit.

[2] Data may not add to totals shown because of independent rounding.

Table 52.—Shipments of bituminous coal to possessions and other areas administered by the United States

Territory	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
American Samoa	119	$2	--------	--------	--------	---------
Puerto Rico	552	7	1,052	$10	464	$4
Virgin Islands	40	(1)	--------	--------	--------	---------

[1] Less than ½ unit.

Table 53.—Bituminous coal[1] imported for consumption in the United States, by countries and customs districts

Country and customs district	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Country:						
Australia	-------	-------	-------	-------	90	$2
Canada	177,672	$1,654	175,070	$1,584	224,298	1,897
Germany, West	-------	-------	51,548	374	-------	-------
Ireland	-------	-------	180	3	-------	-------
Norway	-------	-------	540	31	-------	-------
United Kingdom	-------	-------	-------	-------	6	1
Total	177,672	1,654	227,338	1,992	224,394	1,900
Customs district:						
Boston, Mass	-------	-------	51,548	374	-------	-------
Buffalo, N.Y	2,195	33	3,089	43	1,344	26
Chicago, Ill	-------	-------	-------	-------	36,525	237
Detroit, Mich	427	6	37	1	129	3
Duluth, Minn	7,584	114	1,265	19	10,212	153
El Paso, Tex	-------	-------	74	1	-------	-------
Galveston, Tex	-------	-------	540	31	-------	-------
Great Falls, Mont	13,219	124	19,983	179	10,103	100
Minneapolis, Minn	-------	-------	-------	-------	6	1
Pembina, N. Dak	1,368	19	2,837	40	12,430	177
Philadelphia, Pa	-------	-------	-------	-------	90	2
Portland, Maine	152,879	1,358	147,965	1,304	153,555	1,201
Total	177,672	1,654	227,338	1,992	224,394	1,900

---

[1] Includes slack, culm, and lignite.

Table 54.—World production of bituminous coal, anthracite, and lignite, by countries

(Thousand short tons)

Country	1964	1965	1966	1967	1968 p
North America:					
Canada:					
Bituminous	9,325	9,525	9,313	9,387	8,758
Lignite	1,994	2,064	2,078	2,008	2,250
Greenland: Bituminous	26	22	37	35	e 33
Mexico: Bituminous	2,357	2,211	2,316	2,632	2,871
United States:					
Anthracite (Pennsylvania)	17,184	14,866	12,941	12,256	11,461
Bituminous	484,048	509,045	530,001	548,186	540,428
Lignite [1]	2,950	3,043	3,881	4,490	4,817
South America: [2]					
Argentina: Bituminous	r 366	r 412	r 394	447	519
Brazil: Bituminous (marketable)	r 1,964	r 2,410	r 2,363	2,530	2,606
Chile: Bituminous	1,972	1,904	1,821	1,649	1,742
Colombia: Bituminous	r 5,512	3,417	r 2,756	3,417	3,307
Peru: Bituminous and anthracite	162	142	171	193	e 187
Venezuela: Bituminous	r 40	r 33	37	38	34
Europe:					
Albania: Lignite	322	r 365	r 433	478	e 478
Austria:					
Bituminous	114	65	22	15	--------
Lignite	6,350	6,008	5,824	5,075	4,621
Belgium: Bituminous and anthracite	23,485	21,810	19,289	18,116	16,321
Bulgaria:					
Bituminous and anthracite	671	608	540	515	e 507
Lignite	26,181	26,996	27,143	29,475	e 32,000
Czechoslovakia:					
Bituminous	r 31,086	r 30,450	r 29,466	28,601	28,768
Lignite	83,340	80,707	81,690	78,663	e 82,006
Denmark: Lignite	2,420	2,346	2,185	1,543	e 1,328
France:					
Bituminous and anthracite	58,469	56,601	55,488	52,498	46,199
Lignite	2,474	2,965	2,826	3,230	3,551
Germany:					
Bituminous and anthracite:					
East	2,579	2,438	2,190	1,972	1,874
West	156,750	148,897	138,858	123,506	123,472
Lignite:					
East	283,212	276,499	274,515	266,789	272,491
West	122,294	112,833	108,123	106,666	111,902
Pech coal: West	2,060	1,913	1,280	981	919
Greece: Lignite	4,254	5,600	r 6,175	5,769	6,283
Hungary:					
Bituminous	4,547	4,808	4,806	4,468	4,676
Lignite	30,229	29,845	28,647	25,327	25,321
Ireland: Bituminous and anthracite	255	204	193	201	183
Italy:					
Bituminous and anthracite	519	429	461	452	402
Lignite	1,326	1,114	1,175	2,426	1,905
Netherlands: Bituminous and anthracite	12,655	12,617	11,080	8,890	7,345
Poland:					
Bituminous	129,360	130,989	134,459	136,576	141,757
Lignite	22,355	24,941	27,015	26,369	29,652
Portugal:					
Anthracite	489	472	r 463	488	438
Lignite	111	99	56	43	34
Rumania:					
Bituminous and anthracite [3]	6,495	6,654	6,956	7,403	e 7,496
Lignite	5,766	6,679	7,872	9,152	e 9,976
Spain:					
Bituminous and anthracite	13,444	14,267	r 14,190	13,608	13,485
Lignite	2,870	3,057	r 2,926	2,961	3,097
Svalbard (Spitzbergen): Bituminous:					
Controlled by Norway	487	470	478	471	364
Controlled by U.S.S.R. (shipments)	422	440	e 440	e 440	e 440
Sweden: Bituminous	93	65	44	12	22
U.S.S.R.: [4]					
Bituminous and anthracite	450,701	471,658	r 484,101	497,567	e 500,449
Lignite	159,975	165,181	161,418	158,529	e 154,328
United Kingdom: Bituminous and anthracite	216,863	209,999	195,522	192,792	183,768
Yugoslavia:					
Bituminous	1,391	1,289	1,268	1,001	920
Lignite	31,139	31,733	31,040	28,173	28,546

See footnotes at end of table.

Table 54.—World production of bituminous coal, anthracite, and lignite, by countries—Continued

(Thousand short tons)

Country	1964	1965	1966	1967	1968 [p]
Africa:					
Algeria: Bituminous and anthracite	51	50	[e] 55	[e] 55	[e] 55
Congo, (Kinshasa): Bituminous	[r] 117	[r] 128	121	147	78
Malagasy Republic: Bituminous	4	2	--------	2	--------
Morocco: Anthracite	441	462	497	531	497
Mozambique: Bituminous	270	262	325	311	346
Nigeria: Bituminous	771	816	705	[e] 224	--------
Rhodesia, Southern: Bituminous	3,355	3,868	[e] 3,350	[5] 3,019	[5] 3,278
South Africa, Republic of: Bituminous and anthracite (marketable)	49,513	53,418	52,847	54,344	56,940
Swaziland: Anthracite and bituminous	4	33	74	[e] 86	107
Tanzania: Bituminous	1	2	2	2	3
United Arab Republic: Bituminous	--------	22	[e] 22	NA	--------
Zambia: Bituminous	--------	--------	126	433	633
Asia:					
Afghanistan: Bituminous [6]	125	146	155	168	[e] 220
Burma: Bituminous	11	[r] 17	17	19	10
China, mainland: Bituminous, anthracite, lignite [e]	320,000	330,000	360,000	250,000	330,000
India:					
Bituminous	68,828	[r] 74,033	[r] 74,928	75,184	76,368
Lignite	1,730	2,535	2,831	3,230	4,548
Indonesia: Bituminous	492	430	353	229	194
Iran: Bituminous [6]	302	[r] 314	[r] 314	320	331
Japan:					
Bituminous and anthracite	56,140	54,602	56,601	51,859	51,332
Lignite	762	632	498	403	369
Korea:					
North: Anthracite, bituminous, lignite	15,983	[e] 19,620	[e] 21,500	[e] 23,590	[e] 25,358
South: Anthracite	10,606	11,296	12,801	13,708	11,290
Mongolia, Outer: Lignite and bituminous	780	1,091	1,107	[e] 1,170	[e] 1,378
Pakistan: Bituminous and lignite	1,338	1,621	1,497	1,548	[e] 1,653
Philippines: Bituminous	127	105	83	72	35
Taiwan: Bituminous	5,542	5,571	5,528	5,598	5,527
Thailand: Lignite	115	138	188	369	342
Turkey (salable):					
Bituminous	4,903	4,851	5,394	5,546	[e] 5,512
Lignite	4,267	4,592	5,262	4,925	[e] 6,945
Vietnam:					
North: Anthracite	3,748	[e] [r] 3,858	[e] [r] 3,858	[e] 3,086	[e] 3,307
South: Anthracite	85	--------	--------	--------	--------
Oceania:					
Australia:					
Bituminous	30,689	35,204	37,334	38,875	45,144
Lignite	21,319	23,137	24,400	26,193	25,829
New Zealand:					
Bituminous and anthracite	3,047	2,801	2,721	2,467	2,302
Lignite	175	176	185	186	190
Lignite [7]	[r] 817,930	[r] 812,785	[r] 808,386	792,472	812,799
Bituminous and anthracite [7]	[r] 2,213,164	[r] 2,265,753	[r] 2,306,059	2,203,886	2,273,639
Total, all grades [7]	[r] 3,031,094	[r] 3,078,538	[r] 3,114,445	2,996,358	3,086,438

[e] Estimate. [p] Preliminary. NA Not available. [r] Revised.

[1] Excludes production in State of Texas.

[2] Ecuador produces a negligible amount of coal.

[3] Includes a preponderant share of low-grade bituminous.

[4] Output from U.S.S.R. in Asia (including Sakhalin) included with U.S.S.R. in Europe.

[5] Sales.

[6] Year ended March 20 of year following that stated.

[7] Totals are of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-741/100

Coal—Pennsylvania Anthracite

By Walter C. Lorenz [1]

The reported production of anthracite in the United States in 1968 originated from 13 counties in northeastern Pennsylvania—Berks, Carbon, Columbia, Dauphin, Lackawanna, Lancaster, Lebanon, Luzerne, Northumberland, Schuylkill, Synder, Sullivan, and Susquehanna—from 246 underground mines, 130 strip pits, 127 culm banks, seven river dredges, and 137 preparation plants. The anthracite producing area is divided geographically into the Northern, the Eastern Middle, Western Middle, and Southern fields. The area is further divided into three trade regions by the coal industry—the Wyoming, the Lehigh, and the Schuylkill (fig. 1).

The 1968 production statistics indicated that the general decline in output shown in prior years continued; while, at the same time, the output per man-day increased, and the average per-ton sales price trend

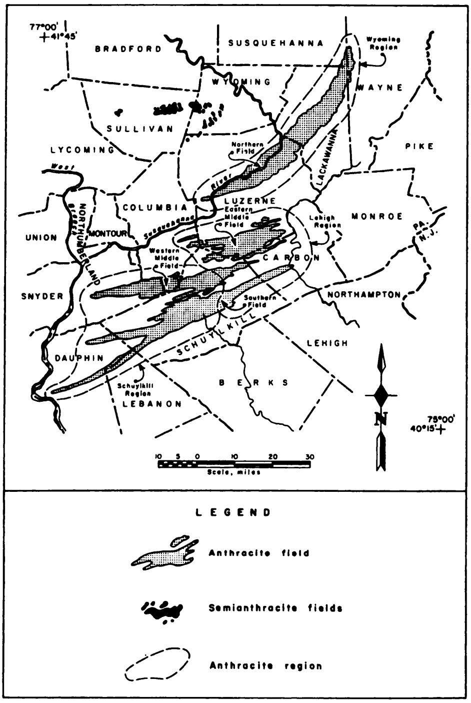

Figure 1.—Coalfields, regions, and counties of the Pennsylvania anthracite area. (Adapted from map in Bureau of Mines Bulletin 585, 1960).

---

[1] Chemical engineer, Pittsburgh Office of Mineral Resources.

Table 1.—Salient statistics of the Pennsylvania anthracite industry

	1964	1965	1966	1967	1968
Production:					
Preparation plants.....short tons..	16,335,700	14,023,269	12,139,106	11,481,582	10,799,260
Dredges....................do....	704,748	699,857	661,017	631,660	605,920
Used at collieries for power and heat................short tons..	143,803	142,829	141,141	142,821	55,653
Total production..........do....	17,184,251	14,865,955	12,941,264	12,256,063	11,460,833
Value...............thousands..	$148,648	$122,021	$100,663	$96,160	$97,245
Average sales realization per short ton on preparation plant shipments (excludes dredge coal):					
Pea and larger....................	$12.38	$11.70	$11.11	$11.53	$12.40
Buckwheat No. 1 and smaller......	$6.56	$6.48	$6.40	$6.35	$6.87
All sizes.......................	$8.93	$8.51	$8.08	$8.15	$8.78
Percentage of total preparation plant shipment (excludes dredge coal):					
Pea and larger....................	40.8	39.0	35.6	34.8	34.6
Buckwheat No. 1 and smaller......	59.2	61.0	64.4	65.2	65.4
Exports [1]..................short tons..	1,575,097	850,630	766,025	594,797	518,159
Consumption apparent [2]........do....	14,400,000	12,900,000	11,400,000	10,800,000	10,160,000
Average number of days worked........	214	204	203	219	217
Average number of men working daily..	13,144	11,132	9,292	7,750	6,932
Output per man per day....short tons..	6.11	6.55	6.87	7.21	7.62
Output per man per year.........do....	1,308	1,336	1,395	1,579	1,654
Quantity cut by machines........do....	417,080	329,328	246,658	146,908	61,245
Quantity mined by stripping......do....	7,177,188	5,938,982	5,253,408	4,740,187	4,696,163
Quantity loaded by machines under ground..................short tons..	3,455,034	3,246,034	2,590,547	1,997,806	1,475,000
Distribution:					
Receipts in New England [3]..do....	331,780	241,638	[4] 149,010	....	....
Exports to Canada [1]..........do....	636,867	642,657	624,280	448,744	401,314
Loaded into vessels at Lake Erie [5] short tons..	216,590	224,460	208,432	206,975	204,682
Receipts at Duluth-Superior [6] short tons..	47,649	11,560	....	....	....

[1] U.S. Department of Commerce, 1964–68 export data does not include shipments to U.S. military forces. See NOTE, tables 2 and 30.

[2] Beginning with 1961 exports to the U.S. military forces in West Germany were taken into consideration. See NOTE, tables 3 and 28.

[3] Commonwealth of Massachusetts, Division on the Necessaries of Life.

[4] Data discontined with September, 1966.

[5] Ore and Coal Exchange, Cleveland, Ohio.

[6] Lake Superior area office, Corps of Engineers, U.S. Army, Duluth, Minn.

was slightly downward over an extended period.

The Federal Government continued to supply Pennsylvania anthracite as a portion of the solid fuel needs of the U.S. Armed Forces, in West Germany.

State and Federal Government programs for environmental activities, such as underground mine fire control, surface subsidence control, refuse or culm bank fire control, mine water drainage control, and reclamation of old strip pits, continued at an accelerated rate, as additional funds became available. The rate of funding of research projects for new or improved uses of anthracite and for advances in mining techniques declined.

Legislation and Government Programs.—The important issues that have emerged in the anthracite region were essentially social in nature. Pollution by acid coal mine drainage and sewage was serious. State and Federal cooperative projects have been undertaken to correct some of the immediate problems, while the State has been making long range plans to prevent future stream contamination. Work has started toward filling abandoned strip pits with existing spoil banks. Long range plans were being projected toward completely eliminating the pits, which are both unsightly and unsafe. Large culm banks, a land use problem, are gradually being eliminated by leveling and by slushing the refuse underground to correct surface subsidence problems. Fires in culm banks and underground coalbeds are gradually being brought under control and quenched as a safety measure in protection of life and property. Appalachia projects are being accomplished in surface subsidence control caused by underground mine voids. These voids are being filled to stabilize the surface as a measure to protect buildings, roads, and other surface structures.

The Federal Government's usual contribution for environmental control activities in the anthracite area has been 75 percent of the funds used, and the State's contribution 25 percent. The work progress of the various environmental control projects in 1968 is as follows:

Project location	Project description	Sponsor	Status of project
	ACID COAL MINE DRAINAGE		
Anthracite fields	Monthly measurements of mine water levels and overflows.	U.S. Geological Survey and U.S. Bureau of Mines.	Continuous.
Schuylkill and Luzerne Counties	Survey on Catawassa Creek to evaluate effectiveness of pollution abatement by plugging three drainage tunnels.	Commonwealth of Pennsylvania	Work in progress.
Schuylkill County	Survey on Rausch Creek to evaluate abatement treatment measures.	do	Do.
Hanover Township, Luzerne County	Construction of Buttonwood drainage trench to control mine water levels on the west side of the Susquehanna River across from Wilkes-Barre.	do	Completed in 1968.
	STRIP MINE REHABILITATION		
Delano Township, Schuylkill County	Appalachia strip mine rehabilitation project on an 80-acre abandoned strip mine site.	Commonwealth of Pennsylvania U.S. Bureau of Mines.	Work in progress 1968.
	BURNING AND NONBURNING CULM BANKS		
Scranton, Lackawanna County	Demonstration project on Baker bank (east) using moving of burning refuse and water quenching method.	U.S. Bureau of Mines	Demonstration project completed 1968.
Do	Demonstration project on Baker bank using an explosive-quenching method.	Commonwealth of Pennsylvania	Do.
Fairview Township, Luzerne County	American Air Pollution Control project on Huber bank using moving-quenching method.	Commonwealth of Pennsylvania and U.S. Public Health Service.	Project completed 1968.
Scranton, Lackawanna County	American Air Pollution Control project on Marvine bank using moving-quenching method.	do	Do.
Do	Project on Marvine bank using moving-quenching method.	Commonwealth of Pennsylvania	Work in progress 1968.
Schuylkill Township, Schuylkill County	American Air Pollution Control project on Mary D bank at Tuscarora using smothering method with limestone refuse dust.	U.S. Public Health Service	Project completed 1968.
Shamokin Borough, Northumberland County	American Air Pollution Control on Fails Slope bank using lime-limestone grout.	U.S. Public Health Service and Commonwealth of Pennsylvania.	First phase completed 1968.
	SURFACE SUBSIDENCE		
Scranton, Pine Brook Section, Lackawanna County.	Appalachia project for hydraulic backfilling of abandoned Pine Brook mine voids.	Commonwealth of Pennsylvania and U.S. Bureau of Mines.	Completed in 1968.
Scranton, Samuel Morse School, Lackawanna County.	Appalachia project for hydraulic backfilling of abandoned mine voids.	do	Do.

Coaldale, Schuylkill County	Appalachia project for hydraulic backfilling of abandoned mine voids.	do	Work in progress 1968.
Scranton, Pine Brook Section, Lackawanna County.	Appalachia project continuation of previous project for backfilling of abandoned Pine Brook mine voids.	do	Do.
Wilkes-Barre, East End Section, Luzerne County.	Appalachia project for hydraulic backfilling of abandoned Blue Coal Corp. mine voids.	do	Do.
Wilkes-Barre, West Heights, Luzerne County	Appalachia project for hydraulic backfilling of abandoned Stanton mine voids.	do	Do.
	UNDERGROUND MINE FIRES		
Laurel Run Borough [1]	Appalachia mine fire control project, which includes exploratory drilling (I), preparation to seal (II), and seal-blocking with sand (II, 2).	U.S. Bureau of Mines and Commonwealth of Pennsylvania.	Phase I completed 1967; phase II, (1) completed 1968; phase II (2) Work in progress 1968.
Centralia Borough, Columbia County	Appalachia mine fire control project, which includes exploratory drilling (I) and seal-blocking underground with fly ash (II).	do	Phase I completed 1967; phase II work in progress 1968.
Scranton,[1] Lackawanna County	Appalachia mine fire control project under Cedar Avenue Section, which includes exploratory drilling (I), sandseal blocking top bed (II, 1), and sandseal underground blocking lower bed (II, 2).	do	Phase I completed 1967; phase II, (1) completed 1968 phase II (2) work in progress 1968.
Carbondale,[1] Lackawanna	Appalachia mine fire control project, which includes exploratory drilling (I), stripping out fire area.	U.S. Bureau of Mines, Carbondale Authority, and Commonwealth of Pennsylvania.	Work in progress 1968.
Shenandoah Borough, Schuylkill County	Appalachia mine fire control project at Kehley Run, which included exploratory drilling (I), and seal-blocking with sand and clay (II).	U.S. Bureau of Mines and Commonwealth of Pennsylvania.	Phase I completed 1968; phase II work in progress 1968.
Troup Borough, Lackawanna County	Appalachia mine fire control project, under southern part of Borough, which included exploratory drilling (I), and seal-blocking (II).	do	Phase I completed 1968; phase II work in progress 1968.
Hazleton, Luzerne County	Appalachia mine fire control project at site of the Hill mine property, which includes exploratory drilling (I).	do	Phase I work in progress 1968.
Swoyersville Borough, Luzerne County	Appalachia mine fire control project, which includes exploratory drilling (I).	do	Do.
Pardeesville, Luzerne County	Mine fire control project at Codicil No. 2 Mine	Commonwealth of Pennsylvania	Work in progress 1968.
Pittston Township, Luzerne County	Mine fire control project	do	Project completed 1968.

---

[1] Familes moved from above fire area and 857 residences were demolished from the three projects.

DOMESTIC PRODUCTION

Anthracite production was 11.5 million tons in 1968, some 800,000 tons, or 6.4 percent, below the 1967 output. About 5 percent of the anthracite was produced by river dredging, 41 percent by strip mining, 32 percent from the reworking of refuse or culm banks, and the remaining 22 percent from underground mines. Approximately 14 percent of the production came from the Eastern Middle field, 25 percent from the Western Middle field, 36 percent from the Southern field, and the remaining 25 percent from the Northern field. Production by the three trade regions was as follows: Lehigh region 22 percent; Schuylkill region 53 percent; and the Wyoming region 25 percent.

The total 1968 anthracite production was valued at $97.2 million, and averaged $8.48 per-ton. The average value of the anthracite sold, by sizes, varied from about $3 per ton for the smallest sizes to nearly $15 per ton for the large sizes, which were generally used as domestic fuel.

CONSUMPTION AND USES

The apparent domestic consumption of anthracite (production minus exports and shipments to U.S. Armed Forces, West Germany) was about 700,000 tons below the 1967 consumption. The decrease reflected a slight decline in sales for residential and commercial heating purposes, and export coal. Overall consumption of anthracite in 1968 was approximately as follows: 5 percent for export; 7 percent for the U.S. Armed Forces, West Germany; 41 percent for residential and commercial heating purposes; 17 percent for electric power production; 11 percent for the iron and steel industry, and the remaining 19 percent divided between other industrial users.

FOREIGN TRADE

Shipments to foreign markets, other than the U.S. Armed Forces, West Germany, during 1968 were about 13 percent less than those made during 1967. The shipments to foreign consumers were usually the larger sizes, such as, lump, egg, stove, chestnut, and pea and were generally furnished by the larger coal operations, because of these operators' ability to ship in the quantities necessary to meet boat schedules.

WORLD REVIEW

Complete data are not available from the world's anthracite producing countries, but the general trend appearing in the foreign production reports indicate a slight decrease of about 1 percent in 1968 world output, compared with that for 1967.

TECHNOLOGY

No significant progress has been made in improving anthracite underground mining technique during the past several years. The Pennsylvania Department of Mines and Mineral Industries studied all facets of the anthracite industry in 1967, with special emphasis on mining methods and techniques, and has instigated research as Coal Research Board Project No. CR–88 on an automated anthracite mining system with semilongwall and pitch capabilities in a current operating deep mine.

The Bureau of Mines conducted grinding experiments on anthracite to determine the finest particle size that could be produced. As anthracite is used in the manufacture of industrial carbons, fine particle size is an important characteristic of the raw materials needed for electrode and refractory applications.

Anthracite use as a blast furnace fuel was investigated. Briquets made from anthracite fines, using a binder and molded into hollow-core forms, were found to be conditionally successful as a substitute for coke in a blast furnace operation.

In conjunction with air pollution research, anthracite, a low sulfur fuel, was burned to determine the retention properties of the ash for the sulfur that was in the coal. The coal was burned without additives and with 10 percent dolomite during the tests. The sulfur retention of the ash was related only to the percentage of coal carbon left in the ash.

Preparation characteristics for the Bottom Red Ash Bed and the Bottom Ross Bed from the Northern Anthracite field were studied by the Bureau of Mines. In addition, laboratory tests were conducted in the separation of anthracite particles from a water-anthracite slurry by atomizing the water and removing the mist in an air current.

Maps of abandoned underground mines in the Wyoming Basin, Northern Anthracite field, were microfilmed as part of a Bureau of Mines continuing program to preserve old mine maps for future studies of subsidence, for mine fire control, and for evaluating building sites.

Table 2.—Standard anthracite specifications approved and adopted by the Anthracite Committee, effective July 28, 1947

Size	Round test mesh (inches)	Percent					
		Oversize maximum	Undersize		Maximum impurities [1]		
			Maximum	Minimum	Slate	Bone	Ash [2]
Broken	Through $4\frac{3}{8}$	--------	----	------	$1\frac{1}{2}$	2	11
	Over $3\frac{1}{4}$ to 3	------	15	$7\frac{1}{2}$	------	------	------
Egg	Through $3\frac{1}{4}$ to 3	5	------	------	$1\frac{1}{2}$	2	11
	Over $2\frac{7}{16}$	------	15	$7\frac{1}{2}$	------	3	11
Stove	Through $2\frac{7}{16}$	$7\frac{1}{2}$	----	------	2	3	11
	Over $1\frac{5}{8}$	------	15	$7\frac{1}{2}$	------	------	------
Chestnut	Through $1\frac{5}{8}$	$7\frac{1}{2}$	------	------	3	4	11
	Over $\frac{13}{16}$	------	15	$7\frac{1}{2}$	------	------	------
Pea	Through $\frac{13}{16}$	10	------	------	4	5	12
	Over $\frac{9}{16}$	------	15	$7\frac{1}{2}$	------	------	------
Buckwheat No. 1	Through $\frac{9}{16}$	10	------	------	------	------	13
	Over $\frac{5}{16}$	------	15	$7\frac{1}{2}$	------	------	------
Buckwheat No. 2 (rice)	Through $\frac{5}{16}$	10	------	------	------	------	13
	Over $\frac{3}{16}$	------	17	$7\frac{1}{2}$	------	------	----
Buckwheat No. 3 (barley)	Through $\frac{3}{16}$	10	------	------	------	------	15
	Over $\frac{3}{32}$	------	20	10	------	------	------
Buckwheat No. 4	Through $\frac{3}{32}$	20	------	------	------	------	15
	Over $\frac{3}{64}$	------	30	10	------	------	------
Buckwheat No. 5	Through $\frac{3}{64}$	30	No limit		------	------	16

[1] When slate content in sizes from broken to chestnut, inclusive, is less than above standards, bone content may be increased by $1\frac{1}{2}$ times the decrease in slate content under the allowable limits, but slate content specified above shall not be exceeded in any event.

A tolerance of 1 percent is allowed on maximum percentage of undersize and maximum percentage of ash content.

Maximum percentage of undersize is applicable only to anthracite as it is produced at preparation plant. Slate is defined as any material that has less than 40 percent fixed carbon.

Bone is defined as any material that has 40 percent or more, but less than 75 percent, fixed carbon.

[2] Ash determinations are on a dry basis.

Table 3.—Summary of monthly developments in the Pennsylvania anthracite industry in 1968

(Thousand short tons, except as otherwise indicated)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year 1968	Change from 1967 (percent)	Year 1967
Production (including mine fuel, local sales, and dredge coal)	965	962	960	926	986	824	853	1,016	953	1,136	994	886	11,461	−6.5	12,256
Shipments (breakers and washeries only, all sizes):															
By rail [1]	271	308	332	417	449	391	395	495	467	517	431	296	4,770	−15.1	5,621
By truck [2]	620	545	470	343	394	350	319	388	365	450	449	480	5,181	−2.5	5,312
Carloadings [3]	5	5	6	8	8	7	8	9	9	10	8	5	91	−17.8	110
Distribution:															
Lake Erie loadings [4]	-----	-----	-----	25	31	10	21	20	27	24	26	21	205	−1.1	207
Upper Lake dock trade: [5]															
Receipts:															
Lake Superior	-----	-----	-----	6	3	6	6	8	6	8	2	-----	46	+3.3	45
Lake Michigan	([11])	([11])	([11])	2	2	([11])	([11])	([11])	([11])	([11])	([11])	([11])	6	−37.0	9
Deliveries (reloadings):															
Lake Superior	3	4	3	4	3	4	4	5	4	5	5	8	54	+17.6	46
Lake Michigan	1	1	([11])	([11])	([11])	([11])	([11])	([11])	1	1	([11])	1	7	−31.6	10
Exports [6]	28	25	17	39	33	68	49	47	75	48	53	37	518	−12.9	595
Industrial consumption and stocks by:															
Electric utilities: [7]															
Consumption	199	199	165	180	182	177	202	203	169	190	157	181	2,203	+.8	2,186
Stocks	1,131	1,065	1,089	1,145	1,228	1,277	1,270	1,294	1,323	1,334	1,366	1,325	1,325	+5.9	1,250
Coke plants:															
Used for carbonizing	45	45	45	42	46	42	40	44	41	45	45	51	[8] 532	+.7	528
Stocks	153	106	85	79	83	82	85	98	124	151	167	154	154	−2.1	157
Stocks on Upper Lake docks: [5]															
Lake Superior	14	10	6	8	8	17	19	23	25	28	26	18	18	+5.5	17
Lake Michigan	2	2	2	4	6	5	5	5	5	4	3	2	2	−25.5	3
Stocks in retail dealer yards: [9]															
Chestnut and larger	167	143	124	134	187	239	248	257	252	231	215	174	174	−20.5	219
Pea	20	21	17	20	26	34	36	28	35	34	31	27	27	−12.9	31
Buckwheat No. 1 and rice	76	68	63	79	88	97	96	115	130	135	128	108	108	+1.9	106
Total	263	232	204	233	301	370	380	400	417	400	374	309	309	−13.2	356
Retail dealer deliveries: [9]															
Chestnut and larger	284	237	153	47	61	59	61	91	102	172	185	218	1,670	−4.1	1,741
Pea	36	34	26	16	9	49	51	70	48	40	19	19	417	−21.0	528
Buckwheat No. 1 and rice	75	58	53	32	31	38	37	43	44	42	33	47	533	−21.2	676
Total	395	329	232	95	101	146	149	204	194	254	237	284	2,620	−11.1	2,945

Wholesale price indexes (1957–59 = 100) :[10]															
F.o.b. car at mines:															
Chestnut	95.8	96.1	96.1	96.1	91.0	91.0	93.4	93.4	95.8	98.2	98.2	101.6	95.6	+6.9	89.4
Buckwheat No. 1	96.4	96.7	96.7	96.7	94.5	94.5	95.4	95.5	97.5	100.6	100.6	105.5	97.6	+7.6	90.7

---

[1] Furnished by initial carriers.
[2] Pennsylvania Department of Mines and Mineral Industries.
[3] Association of American Railroads.
[4] Ore and Coal Exchange, Cleveland, Ohio.
[5] Data furnished by Lake dock operators.
[6] U.S. Department of Commerce. Does not include shipments to the U.S. military forces.
[7] Federal Power Commission.
[8] Data may not add to totals shown because of independent rounding.
[9] Estimated from reports submitted by a selected list of retail dealers located outside the producing region.
[10] Furnished by the Bureau of Labor Statistics from data obtained from authorized trade publications.
[11] Less than ½ unit.

NOTE: According to the Association of American Railroads, 880,076 short tons of anthracite was exported to Europe during 1968 compared with 880,212 tons for 1967. Of this total 819,824 tons was consigned to West Germany and Netherlands, including exports to the U.S. military forces. This compares with 826,968 tons for 1967.

Table 4.—Commercial production of Pennsylvania

Size	From preparation plants					
	Lehigh region			Schuylkill region		
	Rail	Truck	Total [2]	Rail	Truck	Total [2]
Quantity, thousand short tons:						
Lump [3] and broken	------	------	------	------	------	------
Egg	113	4	117	59	3	62
Stove	197	70	266	225	279	504
Chestnut	129	180	309	180	414	593
Pea	82	200	283	98	317	415
Total pea and larger [2]	521	454	975	561	1,013	1,574
Buckwheat No. 1	97	187	284	179	412	591
Buckwheat No. 2 (rice)	31	217	248	106	401	506
Buckwheat No. 3 (barley)	102	164	266	143	490	634
Buckwheat No. 4	141	31	172	162	187	349
Buckwheat No. 5	383	53	436	536	162	697
Other [5]	18	185	203	492	513	1,005
Total buckwheat No. 1 and smaller [2]	773	837	1,610	1,617	2,165	3,782
Grand total [2]	1,294	1,291	2,585	2,179	3,178	5,356
Value, thousands						
Lump [3] and broken	------	------	------	------	------	------
Egg	$1,471	$45	$1,516	$774	$51	$825
Stove	2,532	911	3,442	2,904	3,551	6,456
Chestnut	1,642	2,357	3,999	2,303	5,206	7,509
Pea	831	2,090	2,922	1,019	3,312	4,331
Total pea and larger [2]	6,476	5,403	11,879	7,000	12,120	19,121
Buckwheat No. 1	944	1,815	2,759	1,820	4,114	5,934
Buckwheat No. 2 (rice)	302	2,242	2,544	1,015	3,945	4,960
Buckwheat No. 3 (barley)	836	1,370	2,206	1,125	4,029	5,154
Buckwheat No. 4	812	169	982	972	1,090	2,062
Buckwheat No. 5	2,122	292	2,414	2,743	705	3,448
Other [5]	90	593	683	1,702	1,877	3,579
Total buckwheat No. 1 and smaller [2]	5,106	6,481	11,587	9,377	15,761	25,138
Grand total [2]	11,582	11,885	23,467	16,377	27,881	44,258
Average value per ton:						
Lump [3] and broken	------	------	------	------	------	------
Egg	$13.00	$12.79	$12.99	$13.17	$14.71	$13.26
Stove	12.88	13.08	12.93	12.94	12.72	12.82
Chestnut	12.74	13.07	12.93	12.82	12.59	12.66
Pea	10.09	10.43	10.33	10.37	10.46	10.44
Total pea and larger	12.43	11.90	12.18	12.48	11.97	12.15
Buckwheat No. 1	9.70	9.70	9.70	10.15	9.99	10.03
Buckwheat No. 2 (rice)	9.66	10.33	10.24	9.60	9.85	9.80
Buckwheat No. 3 (barley)	8.16	8.37	8.29	7.85	8.22	8.13
Buckwheat No. 4	5.78	5.45	5.72	6.02	5.82	5.91
Buckwheat No. 5	5.53	5.56	5.54	5.12	4.37	4.95
Other [5]	5.00	3.20	3.36	3.46	3.66	3.56
Total buckwheat No. 1 and smaller	6.61	7.74	7.20	5.80	7.28	6.65
Grand total	8.95	9.21	9.08	7.52	8.77	8.26

---

[1] Includes Sullivan County.
[2] Data may not add to totals shown because of independent rounding.
[3] Quantity of lump included is insignificant.
[4] Less than ½ unit.
[5] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.

anthracite in 1968, by regions and sizes

From preparation plants											
Wyoming region [1]			Total preparation plants			From river dredging			Total		
Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]	Rail	Truck	Total [2]
--------	(4)	(4)	------	(4)	(4)	------	------	------	------	(4)	(4)
52	2	53	224	9	232	------	------	------	224	9	232
215	119	334	636	468	1,104	------	------	------	636	468	1,104
144	302	445	452	896	1,348	------	------	------	452	896	1,348
53	298	351	234	815	1,048	------	------	------	234	815	1,048
463	720	1,183	1,545	2,187	3,732	------	------	------	1,545	2,187	3,732
86	327	413	363	926	1,288	------	------	------	363	926	1,288
50	212	261	187	829	1,016	------	------	------	187	829	1,016
133	162	295	378	816	1,195	------	------	------	378	816	1,195
57	18	75	359	237	596	------	24	24	359	261	620
36	109	146	956	323	1,279	------	7	7	956	331	1,286
27	458	485	537	1,156	1,693	544	31	575	1,081	1,187	2,268
389	1,286	1,675	2,770	4,288	7,067	544	62	606	3,323	4,350	7,673
851	2,007	2,858	4,324	6,475	10,799	544	62	606	4,868	6,537	11,405
--------	(4)	(4)	------	(4)	(4)	------	------	------	------	(4)	(4)
$684	$24	$708	$2,929	$120	$3,048	------	------	------	$2,929	$120	$3,048
2,876	1,593	4,469	8,312	6,055	14,367	------	------	------	8,312	6,055	14,367
1,955	4,091	6,046	5,900	11,655	17,555	------	------	------	5,900	11,655	17,555
612	3,457	4,069	2,463	8,859	11,322	------	------	------	2,463	8,859	11,322
6,128	9,164	15,292	19,604	26,688	46,292	------	------	------	19,604	26,688	46,292
906	3,449	4,355	3,670	9,378	13,048	------	------	------	3,670	9,378	13,048
521	2,248	2,768	1,838	8,434	10,272	------	------	------	1,838	8,434	10,272
1,088	1,347	2,434	3,049	6,745	9,794	------	------	------	3,049	6,745	9,794
328	110	437	2,112	1,369	3,481	------	$112	$112	2,112	1,482	3,598
199	408	607	5,064	1,406	6,470	------	21	21	5,064	1,427	6,491
127	1,062	1,189	1,919	3,532	5,451	$1,981	110	2,090	3,900	3,641	7,541
3,169	8,622	11,791	17,652	30,865	48,516	1,981	243	2,224	19,633	31,107	50,740
9,296	17,787	27,083	37,255	57,553	94,808	1,981	243	2,224	39,236	57,796	97,032
--------	$14.80	$14.80	------	$14.80	$14.80	------	------	------	------	$14.80	$14.80
$13.24	13.28	13.24	$13.10	13.65	13.12	------	------	------	$13.10	13.65	13.12
13.40	13.38	13.40	13.08	12.94	13.02	------	------	------	13.08	12.94	13.02
13.60	13.56	13.58	13.05	13.01	13.02	------	------	------	13.05	13.01	13.02
11.57	11.61	11.61	10.55	10.87	10.80	------	------	------	10.55	10.87	10.80
13.24	12.73	12.93	12.69	12.20	12.40	------	------	------	12.69	12.20	12.40
10.54	10.56	10.56	10.12	10.13	10.13	------	------	------	10.12	10.13	10.13
10.49	10.61	10.59	9.85	10.17	10.11	------	------	------	9.85	10.17	10.11
8.21	8.29	8.26	8.06	8.26	8.20	------	------	------	8.06	8.26	8.20
5.75	5.95	5.80	5.88	5.78	5.84	------	$4.69	$4.69	5.88	5.68	5.80
5.47	3.74	4.17	5.30	4.35	5.06	------	2.96	2.96	5.30	4.32	5.05
4.70	2.32	2.45	3.57	3.05	3.22	$3.64	3.53	3.64	3.61	3.07	3.32
8.15	6.70	7.04	6.35	7.20	6.87	3.64	3.91	3.67	5.91	7.15	6.61
10.92	8.86	9.48	8.62	8.89	8.78	3.64	3.91	3.67	8.06	8.84	8.51

Table 5.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants in 1968, by regions

(Percent)

Size	Lehigh region			Schuylkill region		
	Shipped by rail	Shipped by truck	Total	Shipped by rail	Shipped by truck	Total
Lump [1] and broken	------	------	------	------	------	------
Egg	8.7	0.3	4.5	2.7	0.1	1.2
Stove	15.2	5.4	10.3	10.3	8.8	9.4
Chestnut	10.0	14.0	12.0	8.3	13.0	11.1
Pea	6.4	15.5	10.9	4.5	10.0	7.7
Total pea and larger	40.3	35.2	37.7	25.8	31.9	29.4
Buckwheat No. 1	7.5	14.5	11.0	8.2	13.0	11.0
Buckwheat No. 2 (rice)	2.4	16.8	9.6	4.8	12.6	9.5
Buckwheat No. 3 (barley)	7.9	12.7	10.3	6.6	15.4	11.8
Buckwheat No. 4	10.9	2.4	6.6	7.4	5.9	6.5
Buckwheat No. 5	29.6	4.1	16.9	24.6	5.1	13.0
Other [2]	1.4	14.3	7.9	22.6	16.1	18.8
Total buckwheat No. 1 and smaller	59.7	64.8	62.3	74.2	68.1	70.6
	Wyoming region [3]			Total		
Lump [1] and broken	------	(4)	(4)	------	(4)	(4)
Egg	6.1	0.1	1.9	5.2	0.2	2.2
Stove	25.2	5.9	11.7	14.7	7.2	10.2
Chestnut	16.9	15.0	15.6	10.4	13.8	12.5
Pea	6.2	14.9	12.2	5.4	12.6	9.7
Total pea and larger	54.4	35.9	41.4	35.7	33.8	34.6
Buckwheat No. 1	10.1	16.3	14.4	8.4	14.3	11.9
Buckwheat No. 2 (rice)	5.8	10.6	9.2	4.3	12.8	9.4
Buckwheat No. 3 (barley)	15.5	8.1	10.3	8.8	12.6	11.1
Buckwheat No. 4	6.7	0.9	2.6	8.3	3.7	5.5
Buckwheat No. 5	4.3	5.4	5.1	22.1	5.0	11.8
Other [2]	3.2	22.8	17.0	12.4	17.8	15.7
Total buckwheat No. 1 and smaller	45.6	64.1	58.6	64.3	66.2	65.4

[1] Quantity of lump included is insignificant.
[2] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[3] Includes Sullivan County.
[4] Less than 0.05 per cent.

Table 6.—Sizes of Pennsylvania anthracite (excluding dredge coal) prepared at plants, by regions

(Percent)

Size	Lehigh region					Schuylkill region				
	1964	1965	1966	1967	1968	1964	1965	1966	1967	1968
Lump [1] and broken	------	----	----	----	----	(2)	----	----	----	----
Egg	3.3	3.9	2.7	4.6	4.5	0.9	1.0	0.9	1.2	1.2
Stove	11.8	11.8	11.1	11.0	10.3	11.3	10.3	9.3	9.4	9.4
Chestnut	14.1	14.9	12.4	12.1	12.0	14.2	12.0	12.0	10.7	11.1
Pea	10.5	9.4	7.4	9.0	10.9	9.1	8.4	8.3	8.0	7.7
Total pea and larger	39.5	40.0	33.6	36.7	37.7	35.5	31.7	30.5	29.3	29.4
Buckwheat No. 1	10.4	10.5	11.3	10.5	11.0	11.3	11.9	12.1	11.0	11.0
Buckwheat No. 2 (rice)	10.5	9.5	9.9	8.9	9.6	9.3	10.1	10.2	9.2	9.5
Buckwheat No. 3 (barley)	11.0	10.2	9.1	9.1	10.3	11.7	13.5	13.3	11.1	11.8
Buckwheat No. 4	6.8	5.5	6.2	6.0	6.6	6.6	6.5	7.0	6.7	6.5
Buckwheat No. 5	12.1	12.5	14.8	15.9	16.9	13.3	14.7	14.1	12.8	13.0
Other [3]	9.7	11.8	15.1	12.9	7.9	12.3	11.6	12.8	19.9	18.8
Total buckwheat No. 1 and smaller	60.5	60.0	66.4	63.3	62.3	64.5	68.3	69.5	70.7	70.6
	Wyoming region [4]					Total				
Lump [1] and broken	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
Egg	4.6	4.7	3.4	3.0	1.9	2.5	2.8	2.0	2.6	2.2
Stove	15.2	15.0	13.1	12.0	11.7	12.6	12.1	10.8	10.5	10.2
Chestnut	17.3	16.6	17.2	15.8	15.6	15.2	14.1	13.5	12.4	12.5
Pea	12.9	12.9	12.6	12.1	12.2	10.5	10.0	9.3	9.3	9.7
Total pea and larger	50.0	49.2	46.3	42.9	41.4	40.8	39.0	35.6	34.8	34.6
Buckwheat No. 1	13.9	13.8	15.0	13.3	14.4	11.9	12.2	12.7	11.5	11.9
Buckwheat No. 2 (rice)	9.2	9.2	9.7	9.4	9.2	9.5	9.7	9.9	9.2	9.4
Buckwheat No. 3 (barley)	10.3	10.7	10.8	10.6	10.3	11.1	11.9	11.6	10.4	11.1
Buckwheat No. 4	2.2	3.8	4.7	2.6	2.6	5.8	5.4	6.2	5.4	5.5
Buckwheat No. 5	3.1	2.9	4.3	6.0	5.1	9.9	10.5	11.6	11.9	11.8
Other [3]	11.3	10.4	9.2	15.2	17.0	11.5	11.3	12.4	16.8	15.7
Total buckwheat No. 1 and smaller	50.0	50.8	53.7	57.1	58.6	59.2	61.0	64.4	65.2	65.4

[1] Quantity of lump included is insignificant.
[2] Less than 0.05 percent.
[3] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[4] Includes Sullivan County.

Table 7.—Production of Pennsylvania anthracite in 1968 by regions and counties

(Thousand short tons and thousand dollars)

Source	Rail shipments		Truck shipments		Colliery fuel		Total production [1]	
	Quantity	Value [2]	Quantity	Value [2]	Quantity	Value	Quantity	Value [2]
REGIONS								
Lehigh:								
Preparation plants	1,294	$11,582	1,291	$11,885	8	$76	2,593	$23,543
Schuylkill:								
Preparation plants	2,179	16,377	3,178	27,881	7	66	5,364	44,324
Dredges	544	1,981	62	243	------	------	606	2,224
Total Schuylkill	2,722	18,358	3,240	28,124	7	66	5,969	46,547
Wyoming:								
Preparation plants [3]	851	9,296	2,007	17,787	40	72	2,899	27,155
Total: [1]								
Preparation plants	4,324	37,255	6,475	57,553	56	213	10,855	95,021
Dredges	544	1,981	62	243	------	------	606	2,224
Grand total [1]	4,868	39,236	6,537	57,796	56	213	11,461	97,245
COUNTIES								
Berks, Lancaster, Snyder	544	$1,981	35	$121	------	------	579	$2,102
Carbon	404	3,378	193	1,360	------	------	596	4,738
Columbia	200	2,192	73	575	------	------	273	2,767
Dauphin	13	121	94	427	------	------	107	548
Lackawanna	201	2,018	338	2,975	(4)	$2	540	4,996
Lebanon	------	------	------	------	------	------	------	------
Luzerne	1,322	13,774	2,224	20,329	47	138	3,593	34,241
Northumberland	581	2,821	917	6,906	1	10	1,499	9,737
Schuylkill	1,603	12,952	2,615	24,794	7	63	4,225	37,809
Sullivan	------	------	37	200	------	------	37	200
Susquehanna	------	------	9	108	------	------	9	108
Total [1]	4,868	39,236	6,537	57,796	56	213	11,461	97,245

[1] Data may not add to totals shown because of independent rounding.
[2] Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[3] Includes Sullivan County.
[4] Less than ½ unit.

Table 8.—Pennsylvania anthracite produced, by fields

(Thousand short tons)

Field	1964	1965	1966	1967	1968
Eastern Middle: Breakers and washeries	2,189	2,027	2,009	2,039	1,559
Western Middle:					
Breakers and washeries	4,492	3,428	3,025	2,893	2,840
Dredges	34	36	26	27	17
Total [1]	4,526	3,464	3,051	2,920	2,857
Southern:					
Breakers and washeries	4,592	4,160	3,781	3,604	3,557
Dredges	672	664	635	605	589
Total [1]	5,264	4,824	4,416	4,209	4,146
Northern: Breakers and washeries [2]	5,206	4,551	3,465	3,088	2,899
Total [1]					
Breakers and washeries	16,479	14,165	12,280	11,624	10,855
Dredges	705	700	662	632	606
Grand total [1]	17,184	14,866	12,941	12,256	11,461

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 9.—Pennsylvania anthracite produced in 1968, classified as fresh-mined, culm-bank, and river coal, by fields and regions

(Thousand short tons)

Source	Fresh-mined coal				From culm banks	From river dredging	Total [1]
	Underground mines			Strip pits			
	Mechanically loaded	Hand loaded	Total [1]				
FIELDS							
Eastern Middle	21	20	40	954	565	--------	1,559
Western Middle	139	283	421	1,027	1,392	17	2,857
Southern	345	673	1,018	1,669	870	589	4,146
Northern [2]	970	--------	970	1,046	883	--------	2,899
Total [1]	1,475	975	2,450	4,696	3,709	606	11,461
REGIONS							
Lehigh	21	44	65	1,570	958	--------	2,593
Schuylkill	484	931	1,415	2,080	1,868	606	5,969
Wyoming [2]	970	--------	970	1,046	883	--------	2,899
Total	1,475	975	2,450	4,696	3,709	606	11,461

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Sullivan County.

Table 10.—Production of Pennsylvania anthracite from strip pits

	Mined by stripping (thousand short tons)	Percent of fresh-mined total	Number of men employed	Average number of days worked
1964	7,177	54.9	3,075	217
1965	5,939	52.9	2,349	217
1966	5,258	56.2	2,085	225
1967	4,740	59.3	1,883	237
1968:				
Lehigh region	1,570	96.0	641	238
Schuylkill region	2,080	59.5	794	219
Wyoming region [1]	1,046	51.9	456	273
Total [2] or average	4,696	65.7	1,891	239

[1] Includes Sullivan County.
[2] Data may not add to totals shown because of independent rounding.

Table 11.—Power shovels and draglines used in recovering coal from culm banks and stripping Pennsylvania anthracite, by type of power

Type of power	1966			1967			1968		
	Number of power shovels	Number of draglines	Total	Number of power shovels	Number of draglines	Total	Number of power shovels	Number of draglines	Total
Gasoline	20	1	21	4	6	10	6	5	11
Electric	28	53	81	27	43	70	26	40	66
Diesel	72	149	221	93	140	233	81	144	225
Diesel-electric	3	2	5	1	1	2	----	1	1
Total	123	205	328	125	190	315	113	190	303

Table 12.—Production of Pennsylvania anthracite from culm banks, by regions

(Thousand short tons)

Year	Lehigh region	Schuylkill region	Wyoming region	Total [1]
1964	936	1,580	897	3,413
1965	833	1,380	716	2,930
1966	971	1,390	578	2,938
1967	1,134	1,710	782	3,627
1968	958	1,868	883	3,709

[1] Data may not add to totals shown because of independent rounding.

Table 13.—Pennsylvania anthracite produced by dredges, by rivers, including tributaries

(Thousand short tons and thousand dollars)

Year	Schuylkill River			Susquehanna River			Total [1]		
	Quantity	Value	Average value (per ton)	Quantity	Value	Average value (per ton)	Quantity	Value	Average value (per ton)
1964	98	$324	$3.31	607	$2,035	$3.35	705	$2,359	$3.35
1965	86	289	3.36	614	2,048	3.33	700	2,337	3.34
1966	57	180	3.16	605	2,107	3.48	662	2,287	3.46
1967	39	116	3.00	593	2,140	3.61	632	2,257	3.57
1968	45	157	3.50	561	2,066	3.68	606	2,224	3.67

[1] Data may not add to totals shown because of independent rounding.

Table 14.—Estimated production of Pennsylvania anthracite, by weeks, in 1968 [1]

Week ended—	Thousand short tons	Week ended—	Thousand short tons	Week ended—	Thousand short tons
Jan. 6	149	May 11	178	Sept. 14	261
13	155	18	193	21	292
20	202	25	188	28	235
27	258	June 1	172	Oct. 5	240
Feb. 3	267	8	216	12	225
10	229	15	214	19	246
17	206	22	235	26	235
24	208	29	171	Nov. 2	192
Mar. 2	224	July 6	90	9	250
9	202	13	221	16	247
16	242	20	251	23	250
23	248	27	175	30	200
30	297	Aug. 3	197	Dec. 7	229
Apr. 6	269	10	210	14	239
13	294	17	226	21	229
20	268	24	254	28	189
27	171	31	245		
May 4	167	Sept. 7	210	Total	11,461

[1] Estimated from weekly carloadings as reported by the Association of American Railroads and other factors; adjusted to annual production from Bureau of Mines canvass.

Table 15.—Estimated monthly production of Pennsylvania anthracite[1]

(Thousand short tons)

Month	1964	1965	1966	1967	1968
January	1,668	1,215	1,108	1,101	965
February	1,520	1,006	1,091	989	962
March	1,211	1,256	1,033	979	960
April	1,454	1,127	1,058	952	926
May	1,636	1,264	1,103	1,102	986
June	1,816	1,565	998	995	824
July	1,182	1,209	745	899	853
August	1,306	1,244	1,191	1,132	1,016
September	1,300	1,313	1,145	1,071	953
October	1,337	1,221	1,221	1,073	1,136
November	1,340	1,208	1,145	1,017	994
December	1,414	1,238	1,103	996	886
Total	17,184	14,866	12,941	12,256	11,461

[1] Production is estimated from weekly carloadings as reported by the Association of American Railroads and includes mine fuel, coal sold locally, and dredge coal.

Table 16.—Pennsylvania anthracite loaded mechanically underground, by fields

(Thousand short tons)

Field	Scraper loaders[1]		Pit-car loaders		Hand-loaded face conveyors, all types[2]		Total mechanically loaded[3]	
	1967	1968	1967	1968	1967	1968	1967	1968
Northern	700	606	32	18	709	345	1,440	970
Eastern Middle	7	14	-------	-------	8	6	15	21
Western Middle	12	14	-------	-------	155	125	167	139
Southern	189	197	2	-------	185	148	376	345
Total[3]	908	831	34	18	1,056	625	1,998	1,475

[1] Includes mobile loaders.
[2] Shaker chutes, including those equipped with duckbills.
[3] Data may not add to totals shown because of independent rounding.

Table 17.—Pennsylvania anthracite loaded mechanically underground

(Thousand short tons)

Year	Scraper loaders		Mobile loaders		Conveyor[1] and pit-car loaders		Total[2] loaded mechanically	
	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded	Number of units	Quantity loaded
1964	139	750	31	493	495	2,212	665	3,455
1965	155	907	25	393	403	1,946	583	3,246
1966	151	788	30	328	383	1,474	564	2,591
1967	119	707	21	201	228	1,090	368	1,998
1968	131	710	26	121	184	643	341	1,475

[1] Includes duckbills and other self-loading conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 18.—Trends in mechanical loading,[1] hand loading, and stripping of Pennsylvania anthracite

(Thousand short tons)

Year	Fresh-mined coal							
	Underground					Strip pits		
	Mechanical loading	Percent of total underground	Hand loading	Percent of total underground	Total [2]	Quantity	Percent of total fresh-mined	Total [2]
1964	3,455	58.7	2,434	41.3	5,889	7,177	54.9	13,066
1965	3,246	61.3	2,051	38.7	5,297	5,939	52.9	11,236
1966	2,591	63.4	1,498	36.6	4,088	5,253	56.2	9,342
1967	1,998	61.3	1,260	38.7	3,258	4,740	59.3	7,998
1968	1,475	60.2	975	39.8	2,450	4,696	65.7	7,146

[1] Mechanical loading includes coal handled on pit-car loaders and hand-loaded face conveyors.
[2] Data may not add to totals shown because of independent rounding.

Table 19.—Average sales realization of Pennsylvania anthracite (excluding dredge coal) at preparation plants, by regions and sizes

(Per short ton)

Size	Lehigh region					Schuylkill region				
	1964	1965	1966	1967	1968	1964	1965	1966	1967	1968
Lump [1] and broken	-----	-----	-----	-----	-----	$13.76	-----	-----	-----	-----
Egg	$13.04	$12.95	$12.46	$12.68	$12.99	12.92	$12.65	$12.42	$12.49	$13.26
Stove	13.41	12.62	12.03	12.51	12.93	12.59	11.73	11.30	11.80	12.82
Chestnut	13.44	12.50	11.95	12.46	12.98	12.52	11.68	11.04	11.53	12.66
Pea	11.06	10.09	9.00	9.42	10.33	10.18	9.37	8.66	9.15	10.44
Total pea and larger	12.78	12.01	11.37	11.76	12.18	11.95	11.11	10.51	11.00	12.15
Buckwheat No. 1	9.68	9.28	8.45	9.01	9.70	9.42	8.69	8.68	9.02	10.03
Buckwheat No. 2 (rice)	10.00	9.66	9.32	9.62	10.24	8.99	8 53	8.28	8.67	9.80
Buckwheat No. 3 (barley)	7.21	7.57	7.53	7.78	8.29	6.87	7.12	7.19	7.43	8.13
Buckwheat No. 4	5.33	5.57	5.59	5.48	5.72	4.98	5.26	5.32	5.50	5.91
Buckwheat No. 5	5.17	5.36	5.38	5.46	5.54	4.43	4.31	4.61	4.70	4.95
Other [2]	3.16	2.98	2.99	3.13	3.36	3.37	3.44	3.57	3.95	3.56
Total buckwheat No. 1 and smaller	6.85	6.66	6.26	6.49	7.20	6.25	6.19	6.23	6.18	6.65
Total all sizes	9.19	8.80	7.98	8.42	9.08	8.28	7.75	7.53	7.60	8.26
	Wyoming region [3]					Total				
Lump [1] and broken	$12.42	$12.39	$12.50	$14.96	$14.80	$12.84	$12.39	$12.50	$14.96	$14.80
Egg	12.90	13.12	12.51	12.74	13.24	12.94	12.99	12.48	12.65	13.12
Stove	13.06	12.58	12.17	12.66	13.40	12.92	12.25	11.77	12.25	13.02
Chestnut	13.18	12.51	12.04	12.31	13.58	12.92	12.17	11.59	12.03	13.02
Pea	11.42	10.62	10.34	10.73	11.61	10.82	10.02	9.35	9.75	10.80
Total pea and larger	12.67	12.09	11.65	11.99	12.93	12.38	11.70	11.11	11.53	12.40
Buckwheat No. 1	10.04	9.34	9.01	9.60	10.56	9.69	9.03	8.74	9.19	10.13
Buckwheat No. 2 (rice)	9.73	9.42	9.18	9.59	10.59	9.43	9.03	8.77	9.16	10.11
Buckwheat No. 3 (barley)	6.93	7.42	7.30	7.44	8.26	6.95	7.28	7.28	7.51	8.20
Buckwheat No. 4	5.22	5.82	6.16	5.65	5.80	5.10	5.45	5.56	5.51	5.84
Buckwheat No. 5	4.95	5.08	5.43	4.55	4.17	4.66	4.64	4.93	4.95	5.06
Other [2]	1.87	1.80	2.04	2.45	2.45	2.88	2.86	3.09	3.43	3.22
Total buckwheat No. 1 and smaller	6.97	6.91	6.96	6.58	7.04	6.56	6.48	6.40	6.35	6.87
Total all sizes	9.82	9.46	9.13	8.91	9.48	8.93	8.51	8.08	8.15	8.78

[1] Quantity of lump included is insignificant.
[2] Includes various mixtures of buckwheat Nos. 2 to 5 and coal of relatively low dollar value.
[3] Includes Sullivan County.

Table 20.—Average value of Pennsylvania anthracite from all sources, by regions[1]

(Per short ton)

Region	1967				1968			
	Shipped by rail	Shipped by truck	Colliery fuel	Total	Shipped by rail	Shipped by truck	Colliery fuel	Total
Lehigh	$8.65	$8.15	$8.82	$8.42	$8.95	$9.21	$9.63	$9.08
Schuylkill	6.35	7.92	8.75	7.18	6.74	8.68	9.03	7.80
Wyoming[2]	10.07	8.34	1.16	8.58	10.92	8.86	1.77	9.37
Total	7.70	8.09	1.94	7.85	8.06	8.84	3.83	8.48

[1] Value given for shipments is that at which coal left possession of producing company; does not include selling expenses.
[2] Includes Sullivan County.

Table 21.—Wholesale prices of Pennsylvania anthracite, in 1968, by sizes[1]

(Per short ton)

Size	Winter	Spring discount	Summer-fall	End of year
Egg and stove	$14.00–$15.05	$13.50–$15.05	$14.00–$14.50	$14.50–$15.60
Chestnut	13.75– 14.55	13.25– 14.55	13.75– 14.25	14.25– 15.30
Pea	10.75– 11.55	10.75– 11.55	11.00– 11.50	11.10– 12.45
Buckwheat No. 1	10.10– 10.80	10.00– 10.80	10.25– 10.75	10.60– 11.75
Buckwheat No. 2 (rice)	10.10– 10.80	10.00– 10.80	10.25– 10.75	10.65– 11.75
Buckwheat No. 3 (barley)	8.70– 9.30	9.00– 9.30	9.00– 9.45	9.25– 10.25

[1] As quoted in The Black Diamond Magazine. All prices are per short ton f.o.b. at mines.

Table 22.—Employment at operations producing Pennsylvania anthracite (including strip contractors) in 1968

	Lehigh region	Schuylkill region	Wyoming region[1]	Total	
				1968	1967
Average number of men working daily:					
Underground	37	933	713	1,683	2,287
In strip pits	641	794	456	1,891	1,883
At culm banks	167	287	149	603	570
At preparation plants	497	884	392	1,773	1,893
Other surface	36	287	591	914	1,052
Total excluding dredge operations	1,378	3,185	2,301	6,864	7,685
Dredge operations	---------	68	-----------	68	65
Total	1,378	3,253	2,301	6,932	7,750
Average number of days active:					
All operations except dredges	213	219	218	217	219
Dredge operations	---------	269	-----------	269	284
Average, all operations	213	219	218	217	219
Man-days of labor:					
All operations except dredges	294,133	693,406	501,775	1,489,314	1,682,210
Dredge operations	---------	18,264	-----------	18,264	18,490
Total, all operations	294,133	711,670	501,775	1,507,578	1,700,700
Average tons per man-day:					
All operations except dredges	8.81	7.78	5.90	7.31	6.91
Dredge operations	---------	33.18	-----------	33.18	34.16
Average, all operations	8.81	8.43	5.90	7.62	7.21

[1] Includes Sullivan County.

Table 23.—Employment at operations producing Pennsylvania anthracite (including strip contractors) by counties

County	1967	1968
Berks, Lancaster, Lebanon [1], and Snyder	57	55
Carbon	214	230
Columbia	227	211
Dauphin	107	89
Lackawanna	480	433
Luzerne	3,068	2,534
Northumberland	846	771
Schuylkill	2,735	2,588
Sullivan	14	14
Susquehanna	2	7
Total	7,750	6,932

[1] None employed in Lebanon in 1967.

by States, Provinces, and countries of destination, in short tons

Destination	Pea and larger					Buckwheat No. 1 and smaller					Total all sizes	Percent of Total
	Broken and egg	Stove	Chestnut	Pea	Total	Buckwheat No. 1	Buckwheat No. 2 (Rice)	Buckwheat No. 3 (Barley)	Other	Total		
United States:												
New England States:												
Connecticut	382	8,104	11,290	363	20,139	1,325	3,040	6,845	1,777	12,987	33,126	0.3
Maine	-------	9,119	8,832	194	18,145	1,186	5,241	---------	80	6,507	24,652	.2
Massachusetts	2,567	32,058	19,556	5,106	59,287	12,963	12,853	184	1,915	27,915	87,202	.8
New Hampshire	56	6,079	4,513	346	10,994	2,234	3,038	---------	59	5,331	16,325	.2
Rhode Island	121	3,106	2,624	26	5,877	1,421	372	---------	1	1,794	7,671	.1
Vermont	111	10,381	6,587	1,802	18,881	5,646	11,222	60	6	16,934	35,815	.4
Total	3,237	68,847	53,402	7,837	133,323	24,775	35,766	7,089	3,838	71,468	204,791	2.0
Middle Atlantic States:												
New Jersey	1,790	53,857	134,588	32,705	222,940	58,104	38,989	92,090	318,062	507,245	730,185	7.1
New York	8,602	198,459	164,593	310,863	682,517	184,397	87,807	123,902	210,980	607,086	1,289,603	12,4
Pennsylvania [1]	8,451	383,003	814,081	675,588	1,881,123	877,380	806,551	922,126	1,336,023	3,942,080	5,823,203	56.1
Total	18,843	635,319	1,113,262	1,019,156	2,786,580	1,119,881	933,347	1,138,118	1,865,065	5,056,411	7,842,991	75.6
South Atlantic States: [2]												
Delaware	1,070	9,929	12,888	2,105	25,992	452	167	3,488	18	4,125	30,117	.3
District of Columbia	101	3,833	3,644	553	8,131	1,653	638	222	2	2,515	10,646	.1
Maryland	40	20,909	14,738	1,005	36,692	26,809	1,374	---------	132,100	160,283	196,975	1.9
Virginia	30	3,273	1,408	7,012	11,723	201	181	6	9,182	9,570	21,293	.2
Total	1,241	37,944	32,678	10,675	82,538	29,115	2,360	3,716	141,302	176,493	259,031	2.5
Lake States:												
Illinois	-------	228	1,194	1,119	2,541	53,086	11,962	3,502	40,121	108,671	111,212	1.1
Indiana	-------	2	1,320	6,397	7,719	47	542	398	113,656	114,643	122,362	1.2
Michigan	106	1,524	1,344	80	3,054	8,204	1,301	109	65,342	74,956	78,010	.7
Minnesota	-------	36	6	4	46	6	4	3	30,228	30,241	30,287	.3
Ohio	91	824	697	53	1,665	20,521	14,935	71	93,461	128,988	130,653	1.2
Wisconsin	-------	4,495	4,370	132	8,997	1,264	625	24	6,931	8,844	17,841	.2
Total	197	7,109	8,931	7,785	24,022	83,128	29,369	4,107	349,739	466,343	490,365	4.7
Other States	1,340	65	690	22,324	24,419	46,326	2,577	14,212	179,401	242,516	266,935	2.6
Total United States	24,858	749,284	1,208,963	1,067,777	3,050,882	1,303,225	1,003,419	1,167,242	2,539,345	6,013,231	9,064,113	87.4
Canada:												
Ontario	325	84,730	54,970	16,292	156,317	34,137	12,806	5,657	4,510	57,110	213,427	2.1
Quebec	55	9,938	5,680	961	16,634	8,762	19,509	27,823	1,086	57,180	73,814	.7
Other Provinces	283	2,308	1,049	---------	3,640	---------	350	---------	540	890	4,530	([3])
Total Canada	663	96,976	61,699	17,253	176,591	42,899	32,665	33,480	6,186	115,180	291,771	2.8
Other countries	282,364	427,466	218,877	27,745	956,452	24,121	15	4,544	32,413	61,093	1,017,545	9.8
Grand total	307,885	1,273,726	1,489,539	1,112,775	4,183,925	1,370,245	1,036,099	1,205,266	2,577,894	6,189,504	10,373,429	100.0

[1] Includes "Local sales."

[2] Shipments to other States in the South Atlantic area are included in "Other States."

[3] Less than 0.05 percent.

Table 25.—Truck shipments of Pennsylvania anthracite in 1968, by months, and by State of destination[1]

(Thousand short tons)

Destination	January	February	March	April	May	June	July	August	September	October	November	December	Total[3]	Percent of total trucked
Pennsylvania:														
Within region	235	205	176	135	155	157	121	146	141	180	181	189	2,021	39.0
Outside region	288	242	209	152	175	145	189	172	155	201	183	209	2,269	43.8
New York	43	52	42	26	29	26	29	28	29	36	36	34	409	7.9
New Jersey	30	27	25	19	23	20	15	16	16	20	19	19	248	4.8
Delaware	4	3	2	1	1	2	2	2	2	2	2	3	26	.5
Maryland	18	15	14	9	9	9	12	23	20	9	26	23	188	3.6
District of Columbia	1	1	(2)	(2)	-------	-------	-------	-------	(2)	(2)	(2)	1	2	.1
Other States	2	1	1	1	1	1	1	1	2	3	2	3	18	.3
Total[3]: 1968	620	545	470	343	394	358	319	388	365	450	449	480	5,181	100.0
1967	578	574	500	375	410	344	283	354	391	445	523	535	5,312	100.0

---

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.

[2] Less than ½ unit.

[3] Data may not add to totals shown because of independent rounding.

Table 26.—Shipments of Pennsylvania anthracite, by destinations[1]

(Thousand short tons)

Destination	1964	1965	1966	1967	1968
TRUCK SHIPMENTS					
Pennsylvania:					
Within region	3,231	2,712	2,343	1,986	2,021
Outside region	3,284	3,015	2,685	2,485	2,269
New York	692	521	477	418	409
New Jersey	501	440	392	286	248
Delaware	34	30	26	23	26
Maryland	78	63	69	89	188
District of Columbia	5	7	8	6	2
Other States	36	24	21	20	18
Total [2]	7,862	6,812	6,021	5,312	5,181
RAIL SHIPMENTS					
New England States	381	298	221	174	163
New York	1,317	1,056	957	703	606
New Jersey	641	654	399	323	263
Pennsylvania	2,209	1,780	1,247	1,052	846
Delaware	12	6	4	5	1
Maryland	230	184	210	83	32
District of Columbia	19	12	9	10	9
Virginia	12	39	29	13	6
Ohio	162	142	121	85	98
Indiana	72	80	67	51	43
Illinois	102	121	103	114	108
Wisconsin	29	21	19	16	14
Minnesota	21	39	25	22	13
Michigan	51	84	54	41	42
Other States	232	272	305	244	233
Total United States [2]	5,493	4,788	3,768	2,936	2,476
Canada	513	464	434	306	308
Other foreign countries	1,444	1,170	741	894	697
Grand total [2]	7,450	6,422	4,943	4,136	3,481

[1] Compiled from reports of Pennsylvania Department of Mines and Mineral Industries; does not include dredge coal.

[2] Data may not add to totals shown because of independent rounding.

Table 27.—Consumption of Pennsylvania anthracite in the United States, by consumer categories

(Thousand short tons)

Year	Residential and commercial heating [1]	Colliery fuel	Electric utilities [2]	Cement plants	Iron and steel industry		Other industrial [1]	Unaccounted for [1]
					Coke making	Sintering and pelletizing [3]		
1964	7,550	144	2,239	153	492	1,014	2,713	95
1965	6,628	143	2,158	269	507	966	2,071	158
1966	5,622	141	2,192	187	515	897	1,715	131
1967	5,035	143	2,186	239	528	819	[r]1,800	50
1968	4,759	56	2,203	181	532	748	1,635	46

[r] Revised.

[1] Calculated.

[2] Federal Power Commission.

[3] Annual Statistical Report, American Iron and Steel Institute.

Table 28.—U.S. exports of anthracite by countries and customs districts

(Thousand short tons and thousand dollars)

	1967		1968	
	Quantity	Value	Quantity	Value
COUNTRY				
Argentina	2	$23	2	$33
Australia	4	96	4	99
Brazil	2	23	3	73
Canada	449	5,751	401	4,979
Chile	1	12	1	13
France	1	17	(1)	6
India	5	62	(1)	1
Italy	45	488	59	585
Japan	8	108	2	24
Mexico	11	141	12	157
Panama	8	85	-------	--------
Philippines	(1)	12	1	17
Rumania	11	131	-------	--------
Surinam	2	34	1	14
Thailand	5	36	-------	--------
Venezuela	8	135	9	151
Vietnam, South	26	396	22	365
Yugoslavia	(1)	2	1	11
Other	7	70	(1)	25
Total	595	7,622	518	6,553
CUSTOMS DISTRICT				
Baltimore	14	$139	1	$8
Buffalo	220	3,103	137	1,982
Detroit	2	30	7	103
Houston	4	96	4	132
Laredo	11	141	12	157
Mobile	(1)	2	1	13
New Orleans	9	117	-------	--------
New York City	4	51	4	49
Norfolk	2	31	1	16
Ogdensburg	50	653	54	654
Philadelphia	277	3,231	295	3,418
St. Albans	1	11	2	20
Seattle	1	11	-------	--------
Other	(1)	6	(1)	1
Total	595	7,622	518	6,553

[1] Less than ½ unit.

Note: According to the Association of American Railroads, 880,076 short tons of anthracite was exported to Europe during 1968 compared with 880,212 tons for 1967. Of this total 819,824 tons was consigned to West Germany and Netherlands, including exports to the U.S. military forces. This compares with 826,968 tons for 1967.

Table 29.—World production of anthracite, by countries

(Thousand short tons)

Country	1964	1965	1966	1967	1968 [p]
Belgium	8,710	7,934	7,336	[r] 6,331	[e] 5,622
Bulgaria	244	209	[r] 211	[e] 209	[e] 209
China, mainland [e]	23,148	24,251	25,353	19,842	22,046
France	13,511	13,660	13,950	[r] 13,268	12,125
Germany, West	16,217	15,526	13,725	12,103	[e] 11,574
Ireland	169	130	133	[r] 122	114
Italy	10	7	---------	---------	---------
Japan	1,884	1,797	1,777	1,669	1,641
Korea:					
North [e]	12,846	15,983	17,086	18,739	20,393
South	10,606	11,296	12,801	13,708	11,290
Morocco	441	462	497	581	497
Netherlands [1]	4,639	4,884	4,845	[r] 4,248	[e] 4,740
Peru	35	9	15	6	NA
Portugal	489	472	463	488	438
Rumania [e]	17	17	17	17	NA
South Africa, Republic of	1,450	1,375	1,187	1,411	1,505
Spain	2,954	3,059	3,028	3,058	3,068
Swaziland	4	33	74	[e] 86	107
U.S.S.R.	[r] 82,561	[r] 84,290	[r] 84,630	[r] 85,031	[e] 85,429
United Kingdom	5,150	4,707	4,986	[r] 4,583	[e] 4,630
United States (Pennsylvania)	17,184	14,866	12,941	12,256	11,461
Vietnam:					
North [e]	3,748	3,858	3,858	3,086	3,307
South	85	---------	---------	---------	---------
Total	[r] 205,602	[r] 208,825	[r] 208,913	[r] 200,737	200,196

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Less than 10 percent volatile matter.

NOTE: Insignificant quantities produced in New Zealand and possibly other countries. An undetermined amount of semianthracite is included in figures for some countries.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/67

Cobalt

By Gilbert L. DeHuff[1]

Government sales of cobalt continued to be an important supply factor in 1968. Demand was off somewhat from that of the previous year, but the total consumed for the year held up fairly well, contrary to earlier indications. Imports showed a gain.

Legislation and Government Programs.—General Services Administration (GSA) continued its off-the-shelf sales of cobalt metal until the approximate 4 million pounds of its July 3, 1967, offering were sold by early March 1968. The sales were made out of a stock of granules, briquets, rondelles, broken cathodes, and small lumps or pellets, held in the Defense Production Act (DPA) inventory. In subsequent competitive bid offerings in each of the last three quarters of the year, 2.83 million pounds of cobalt were sold from the DPA stocks on an unrestricted basis except as to total quantities offered. Rondelles were no longer among the items offered, and the last offering consisted only of granules and broken cathodes.

As of December 31, 1968, the total U.S. Government stockpile inventory was 90,295,595 pounds of cobalt. Of this quantity, 79,702,791 pounds was stockpile grade.

Table 1.—Salient cobalt statistics

(Thousand pounds of contained cobalt)

	1964	1965	1966	1967	1968
United States:					
Consumption	10,650	13,595	14,205	13,976	13,000
Imports for consumption	12,443	15,408	18,823	8,215	9,068
Stocks, Dec. 31: Consumer	1,420	1,590	1,996	2,471	2,139
Price: Metal—per pound	$1.50	$1.50	$1.65	$1.85	$1.85
World: Production	38,150	40,624	46,782	44,028	43,086

DOMESTIC PRODUCTION

Cobalt continued to be produced in the United States as a byproduct of iron ore mining, and at least two companies—Basic Inc. and Roland F. Beers Inc.—were investigating nickel-copper-cobalt sulfide deposits in Maine. In Idaho, The Hanna Mining Co. completed a drilling program at the Blackbird cobalt-copper property in which it acquired controlling interest in 1967. In order to determine the possibilities for commercial development, the company was engaged in extensive metallurgical research, including the study of metal extraction by chemical methods at a pilot plant.

CONSUMPTION AND USES

Consumption of cobalt in the United States, as shown in table 5, decreased for the second year in succession. Permanent magnets and nonferrous alloy applications continued to be the principal uses.

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Cobalt materials consumed by refiners or processors in the United States

(Thousand pounds of contained cobalt)

Form [1]	1964	1965	1966	1967	1968
Alloy and concentrate	1,174	1,188	1,214	1,168	1,184
Metal	1,392	1,669	1,699	1,618	1,831
Hydrate	21	32	35	18	14
Other	9	3	6	2	11

[1] Total consumption is not shown because some metal, hydrate, and carbonate originated from alloy an concentrate.

Table 3.—Cobalt products[1] produced and shipped by refiners and processors in the United States

(Thousand pounds)

Product	1967				1968			
	Production		Shipments		Production		Shipments	
	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content	Gross weight	Cobalt content
Oxide	485	336	476	334	399	280	365	256
Hydrate	579	290	614	298	658	318	559	264
Salts:								
Acetate	1,063	255	1,055	253	1,480	355	1,482	355
Carbonate	632	325	595	276	524	244	556	258
Sulfate	459	105	459	102	1,166	239	1,087	226
Other	328	73	316	65	437	118	422	95
Driers	9,751	671	9,496	598	9,697	650	9,541	628
Total	13,297	2,055	13,011	1,926	14,361	2,204	14,012	2,082

[1] Figure on metal withheld to avoid disclosing individual company confidential data.

Table 4.—Cobalt consumed in the United States, by end uses

(Thousand pounds of contained cobalt)

Use	1967	1968
Steel (ingots and castings):		
High speed and tool	514	553
Stainless steel	136	145
Alloy (excluding stainless and tool)	516	470
Carbon steel	W	W
Other steel	W	W
Cast irons	W	W
Cutting and wear resistance materials:		
Cemented or sintered carbides	486	516
Other materials	430	191
Welding and hardfacing rods and materials	864	495
Magnetic alloys	2,486	2,700
Nonferrous alloys	3,625	3,061
Electrical materials	759	954
Chemical and ceramic uses:		
Catalysts	626	721
Ground coat frit	286	201
Glass decolorizer	70	67
Pigments	134	211
Other	63	29
Miscellaneous and unspecified	1,390	863
Total [1]	12,384	11,175
Salts and driers: Lacquers, varnishes, paints, inks, pigments, enamels, glazes, feed, electroplating, etc. (estimate)	1,592	1,826
Grand total	13,976	13,000

W Withheld to avoid disclosing individual company confidential data, included in miscellaneous and unspecified.

[1] Data may not add to totals shown due to individual rounding.

Table 5.—Cobalt consumed in the United States, by forms

(Thousand pounds of contained cobalt)

Form	1964	1965	1966	1967	1968
Metal	8,265	10,872	11,768	11,610	10,456
Oxide	958	961	768	654	573
Purchased scrap	148	87	48	120	145
Salts and driers	1,279	1,675	1,621	1,592	1,826
Total [1]	10,650	13,595	14,205	13,976	13,000

[1] Data may not add to total shown due to individual rounding.

PRICES

The producer price for metal granules containing 99 percent or more cobalt, in 500-pound lots, remained throughout the year at $1.85 per pound, f.o.b. New York or Chicago. On May 27, Sherritt Gordon Mines Ltd. cut the price of its S-grade powder 18 cents to $1.85 per pound and cut the price for its briquets 15 cents to $1.88 per pound, thereby becoming more competitive for these items.

Cobalt metal sold off-the-shelf by General Services Administration in the first part of the year continued to be priced at $1.70 per pound of contained cobalt, f.o.b. carrier's conveyance at Government storage locations, for metal of 99.50 percent purity. For each 0.5-percent decrease in cobalt content the price was lowered $0.01 per pound. Subsequent GSA sales through competitive bids brought prices ranging from $1.5761 to $1.801 per pound.

FOREIGN TRADE

Exports of unwrought cobalt metal and alloys and of waste and scrap totaled 2,178,336 pounds, gross weight, having a value of $2,635,779. These exports went to 21 countries with West Germany and Japan taking the greater part—807,348 pounds ($1,369,677) and 648,017 pounds ($336,723), respectively. Exports of wrought cobalt metal and alloys were 361,107 pounds, gross weight, having a value of $1,712,180 and going to 35 countries.

The imports of cobalt salts and compounds totaled in table 7 came from the United Kingdom, Canada, West Germany, and Japan.

Table 6.—U.S. imports for consumption of cobalt metal and oxide, by countries

(Thousand pounds and thousand dollars)

Country	Metal				Oxide			
	1967		1968		1967		1968	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Australia	60	$59	------	------	------		------	------
Belgium-Luxembourg	1,826	3,722	3,404	$6,146	1,028	$1,642	1,184	$2,108
Canada	783	1,518	1,032	1,909	16	27	2	5
Congo (Kinshasa)	3,186	5,549	2,649	4,630	------	------	------	------
France	889	1,611	776	1,418	------	------	------	------
Germany, West	188	311	23	51	------	------	------	------
Japan	3	3	8	9	------	------	(1)	(1)
Netherlands	27	37	30	32	------	------	------	------
Norway	605	1,228	741	1,370	------	------	------	------
Switzerland	------	------	(1)	(1)	(1)	------	------	------
United Kingdom	379	382	398	447	------	------	------	------
Western Africa, n.e.c	------	------	158	273	------	------	------	------
Total	7,946	14,420	9,219	16,285	1,044	1,670	1,186	2,113

(1) Less than ½ unit.

Table 7.—U.S. imports for consumption of cobalt, by classes

(Thousand pounds and thousand dollars)

Year	Metal		Oxide		Salts and compounds		Total	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Cobalt content[e]
1966	17,871	$27,734	1,279	$1,411	150	$81	19,300	18,823
1967	7,946	14,420	1,044	1,670	167	200	9,157	8,215
1968	9,219	16,285	1,186	2,113	107	90	10,512	9,068

[e] Estimate.

WORLD REVIEW

Active exploration and development of nickel deposits throughout the world in 1968 may result in the development of new cobalt sources. These projects are discussed in the Nickel chapter.

Belgium.—Prompted by a considerable expansion of its markets for cobalt salts and oxides, Metallurgie Hoboken S.A. was engaged in appreciably increasing production of the former and planned to increase its output of the latter. Union Minière S.A. holds a substantial interest in Metallurgie Hoboken S.A.

Canada.—Several hundred Ontario silver-cobalt occurrences were described in a report containing 15 sketch maps.[2] Cobalt deliveries by The International Nickel Co. of Canada, Ltd., (Inco) were 1,790,000 pounds in 1968, compared with 2,210,000 pounds in 1967, 2 million pounds in 1966, and 2,020,000 pounds in 1965. Production of cobalt by Sherritt Gordon Mines Ltd. increased to 893,609 pounds in 1968 from 764,073 pounds in the preceding year. Its cobalt sales for the 2 years were 985,046 and 872,522 pounds, respectively.

Falconbridge Nickel Mines Ltd. shipped its nickel-copper matte to its refinery at Kristiansand, Norway, where the cobalt content was recovered. The company's cobalt deliveries increased substantially. The source for almost all the cobalt produced by these 3 companies continued to be the nickel-copper ores of Ontario and Manitoba. Silver-cobalt ores of the Cobalt and Gowganda districts of Ontario were smelted to speiss by the Cobalt Refinery Division of Kam-Kotia Mines Ltd. at its Cobalt, Ontario, smelter and refinery. This speiss was shipped under contract to

---

[2] Sergiades, A. O. Silver-Cobalt Calcite Vein Deposits of Ontario. Miner. Res. Circ. 10, Ontario Dept. Mines, Toronto, Canada, 1968, 498 pp.

Table 8.—World production of cobalt by countries

(Short tons of contained cobalt)

Country [1]	1964	1965	1966	1967	1968 [p]
Australia (content of zinc concentrates)	82	100	[r] 94	164	[e] 160
Canada [2]	1,592	1,824	1,756	1,802	1,744
Congo (Kinshasa)	8,461	9,246	12,453	[3] 10,712	[e] 11,000
Cuba (recoverable from sulfide)[e]	770	880	1,010	1,150	1,200
Finland [4]	1,856	1,646	[r] 1,585	[e] 1,984	[e] 1,875
Germany, West	1,593	1,495	1,225	973	[e] 880
Morocco (content of concentrate)	1,850	2,019	2,198	2,125	[e] 1,840
U.S.S.R. (metal)[e]	1,300	1,400	1,400	1,500	1,500
Zambia (cathode metal and other products)	1,571	1,702	1,670	1,604	1,319
Total [5]	[r] 19,075	[r] 20,312	[r] 23,391	22,014	21,518

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Cobalt was produced in Bulgaria, East Germany, Poland, and Uganda but production data are not available. U.S. figure is withheld to avoid disclosing individual company confidential data. No estimates for these countries are included in the world total.

[2] Cobalt in all forms. Excludes the cobalt content of nickel-oxide sinter shipped to the United Kingdom by International Nickel, but includes the cobalt content of Falconbridge shipments of nickel-copper matte to Norway.

[3] Includes 6,465 tons in cathodes and 3,253 tons in granules.

[4] Content of cobaltous pyrite.

[5] Total is of listed figures only.

Belgium for treatment. Changes to be made by 1970 at the company's Ontario plant will permit conversion to cobalt and nickel oxides at that location.

Congo (Kinshasa).—The World Bank agreed to mediate between Union Miniere S.A. and the Congolese (Kinshasa) Government in the matter of compensation for nationalization of the company's mines and other holdings.

Finland.—Production of cobalt metal began late in 1967 with the start of operations at Outokumpu Oy's new cobalt refinery at Kokkola. The plant used Sherritt Gordon's hydrometallurgical process in treating cobaltous pyrite concentrate and sinter, formerly shipped to West Germany. Cobalt metal production was 19 short tons in 1967 and 557 tons in 1968.

India.—Geologists of the Geological Survey of India discovered a vein of cobaltous pyrite north of the Ranganadi River in the Subansiri district of the Northeast Frontier Agency. The exposure, showing a width of 4 feet, was estimated to contain 2.2 percent cobalt. It was hoped that the discovery would result in satisfying India's cobalt requirements of approximately 50 tons per year, now supplied by imports.

Japan.—Imports of cobalt metal were approximately 2,000 short tons in 1968 compared with 2,600 tons in 1967. The decrease was attributed to a drop in production of magnets, combined with a carryover of large stocks from the previous year. Magnet production uses approximately 80 percent of Japan's cobalt imports.[3]

Morocco.—Technoexport, an agency of the U.S.S.R., signed an agreement to undertake geological, geochemical, and geophysical surveys for cobalt in eastern Morocco and to conduct laboratory tests. The work will be in the Bou Azzer region of the Great Atlas Mountains, where Morocco's only cobalt mine continued to produce.[4]

Zambia.—In the fiscal year ending June 30, 1968, Rhokana Corporation Ltd. produced 1,499 short tons of cobalt compared with the 1,717 tons produced the previous fiscal year and the 1,694 tons produced in 1965–66. A 2-month plant shutdown for repairs and modifications accounted for the drop. Of a total of 33,265 tons of cobalt-copper concentrate produced in the fiscal year ending June 30, 1968, by the Chibuluma mine of Roan Selection Trust Ltd., 4,593 tons were sold, and the balance was stockpiled. Ore reserves remaining at the Chibuluma and Chibuluma West mines as of June 30, 1968, were estimated to be 6,768,000 tons containing 5.00 percent copper and 0.21 percent cobalt, irrespective of allowances for the dilution expected in mining. Ore production during the fiscal year totaled 758,774 tons containing 4.12 percent copper and 0.15 percent cobalt. As of June 30, 1968, total estimated reserves of Baluba Mines Ltd., under development by Roan Selection Trust near Luanshya, were 112 million tons containing 2.41 percent copper and 0.16 percent cobalt. A crosscut to the ore on the 400 level obtained a 400-ton bulk sulfide sample for metallurgical testing in the pilot mill at Luanshya. Drilling continued for the purpose of confirming ore reserves below the 800 level.

TECHNOLOGY

A method for recovering cobalt from nickel-cobalt alloys was developed by the Bureau of Mines.[5] Using alloys containing up to 5.5 percent cobalt for the anode, the nickel and cobalt were separated by electrorefining in a molten potassium chloride-lithium chloride-nickel chloride electrolyte, with high-purity nickel metal being deposited on a nickel cathode. In the course of this operation, the nickel content of the electrolyte was gradually replaced by cobalt from the anode. The remaining nickel was then removed by electrorefining with a cobalt anode. This anode was then replaced by one of carbon, and the cobalt was electrowon from the electrolyte.

Bureau studies of the effects of cobalt additions to certain stainless steels demonstrated that the ferrite content of 17-7 PH stainless steel can be advantageously reduced without adversely affecting room-temperature tensile properties, hardness, or impact strength.[6] The addition of 2 percent by weight of cobalt improved tensile and yields strengths without loss of ductility, and a 1-percent addition improved ductility with only a slight loss in strength.

---

[3] Metal Bulletin (London). No. 5367, Jan. 21, 1969, p. 17.

[4] Mining Journal (London). V. 271, No. 6954, Nov. 29, 1968, p. 431.

[5] Sullivan, T. A., B. E. Barton, and F. R. Cattoir. An Electrolytic Process for Separating Nickel and Cobalt. BuMines Rept. of Inv. 7082, 1968, 17 pp.

Additions of up to 4 percent cobalt in AM 350 (AISI 633) stainless steel, a widely used molybdenum-bearing stainless, did not increase precipitation hardening.[7]

Very powerful permanent magnets were made at the Bell Telephone Laboratories from solid solutions of samarium-cobalt and samarium-copper compounds.[8] Coercive forces of up to 28,700 oersteds were obtained in the annealed alloy—probably the highest value ever obtained for a solid material possessing substantial magnetic moment at room temperature. Annealed samples of similar solid solutions of cerium-cobalt and cerium-copper compounds were found to have intrinsic coercive forces of 9,000 oersteds.

Testing of pilot-plant ingots under mill conditions showed that addition of 3 percent cobalt to the standard titanium alloy containing 6 percent aluminum and 4 percent vanadium, widely used as a fastener in aerospace applications, increased strength (particularly fatigue strength) without loss of ductility or workability.[9] Thermal stability was maintained up to 400° C. Earlier research had resulted in unsatisfactory thermal stability for a 4-percent-cobalt addition, although a notable increase in strength for both 4-percent and 2-percent additions had been registered. It was concluded that the cobalt-containing alloy was superior to the standard alloy under dynamic stress and particularly for high amplitudes. It was believed to have promise for high-strength fastener applications.

Other developments of interest included a polyester card with a thin, nickel-cobalt magnetic film on each side, a possible replacement for the ordinary punched-paper computer card. Besides being smaller, the plastic card has significantly greater information capacity, and it is obedient to an all-air transport system. Lasers were being used to weld cobalt-base alloys. They were stated to be particularly advantageous in the welding of permanent magnets. Numerous technical papers were presented on cobalt metal, alloys and alloy systems, tools and wear-resistant materials, cast irons and alloy steels, magnetic materials, films and coatings, and other applications.[10]

---

[6] Tilman, M. M. Ferrite Control by Cobalt Additions to a Semiaustenitic Stainless Steel. BuMines Rept. of Inv. 7107, 1968, 14 pp.

[7] Tilman, M. M. Effects of Cobalt on Precipitation Hardening of AM 350 Stainless Steel. BuMines Rept. of Inv. 7121, 1968, 6 pp.

[8] Nesbitt, E. A., R. H. Willens, R. C. Sherwood, E. Buehler, and J. H. Wernick. New Permanent Magnet Materials. Appl. Phys. Letters, v. 12, No. 11, June 1, 1968, pp. 361–362.

[9] Diderrich, E., K. Rudinger, G. Turlach, and L. Habraken. Addition of Cobalt to the Ti–6A1–4V Alloy. J. Metals, v. 20, No. 5, May 1968, pp. 29–37.

[10] Cobalt—A Quarterly Publication on Cobalt and Its Uses. Cobalt Information Center, Battelle Memorial Institute, Columbus, Ohio. Nos. 38–41, March, June, September, and December 1968.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/20

Coke and Coal Chemicals

By Leonard Westerstrom [1]

Coke production in the United States totaled 63.7 million tons in 1968, down slightly from the 64.6 million tons produced in 1967. Both oven and beehive plants contributed to the decrease. Oven coke production in 1968 was 62.9 million tons or 1.4 percent below the 1967 output of 63.8 million tons. Production of beehive coke in 1968 totaled 775,000 tons, which was 3.8 percent less than the 806,000 tons produced in 1967.

Although coke production declined 900,000 tons in 1968, pig iron production increased 1.7 million tons. Less coke was required at blast furnace plants as the coke rate, the amount of coke required to produce 1 ton of pig iron, fell from 1,287.8 pounds in 1967 to 1,263.4 pounds in 1968.

Coke production exceeded demand, especially in the second half of the year. Beginning in July, stocks of oven coke increased each month reaching an alltime peak of 6.0 million tons by year end 1968. This supply was equivalent to 36.1 days' production at the December rate of output.

Blast furnaces continued to use the bulk of the Nation's coke production, receiving 91.2 percent of total shipments from producers. The remaining coke was consumed principally in foundries and miscellaneous industrial plants. A very small quantity was sold for residential heating. This latter market is rapidly declining and is expected to be nonexistent within the next few years.

Breeze production in 1968 was 4.1 million tons compared with 4.0 million tons in 1967. Breeze is primarily used by integrated coke producers for sintering iron ore and for raising steam; it is unsuitable for most metallurgical applications because of its size and high ash content. However, about one-third of the 1968 output was sold for use mainly as a reductant in electric furnaces that smelt phosphate rock to pro-

Table 1.—Salient coke statistics [1]

	1964	1965	1966	1967	1968
United States:					
Production:					
Oven coke----thousand short tons--	60,908	65,198	65,959	63,775	62,878
Beehive coke--------------do----	1,236	1,657	1,442	806	775
Total--------------------do----	62,145	66,854	67,402	64,580	63,653
Imports--------------------do----	103	90	96	92	94
Exports--------------------do----	524	834	1,066	710	792
Producers' stocks, Dec. 31--------do----	1,972	2,703	3,079	5,468	5,985
Consumption, apparent-----------do----	62,637	65,379	66,019	61,572	62,438
Value of coal-chemical materials used or sold--------------------thousands--	$290,952	$311,407	$309,143	$292,579	$282,922
Value of coke and breeze used or sold thousands--	[r] 1,125,814	[r] 1,118,070	[r] 1,166,663	[r] 1,107,144	1,175,503
Total value of all products used or sold thousands--	1,416,766	1,429,477	1,475,806	1,399,723	1,458,425
World production:					
Hard coke--------thousand short tons--	329,077	342,039	342,194	334,531	315,272
Gashouse and low-temperature coke thousand short tons--	41,141	38,413	37,043	34,610	19,379

[r] Revised.

[1] Data may not add to totals shown because of independent rounding.

---

[1] Industry economist, Division of Mineral Studies.

duced elemental phosphorus. Sales of breeze were 9.1 percent higher than in 1967.

Coal costs at coking plants in 1968 were on the average 1 cent less per ton than in 1967. Coal cost increased slightly at plants in most States, but averaged lower in Pennsylvania, Minnesota, and Wisconsin. Delivered prices of coal to oven coke plants ranged from $8.13 to $12.47 per ton. The average value of bituminous coking coal at slot ovens was $10.01 and at beehive ovens was $5.71. West Virginia, Pennsylvania, and Kentucky continued to be the main suppliers of coal to coke plants. Receipts from these States were 75.4 million tons or 80.0 percent of total coking coal shipments in 1968.

Production of coal chemicals normally parallels oven-coke output, and this was true of all primary coal chemicals in 1968. Production of tar, ammonia, light oil, and coke-oven gas registered decreases ranging between 3 and 8 percent under the quantities produced in 1967. Yields of the basic chemical raw materials also declined. Processing of crude tar and crude light oil for the production of various tar and light oil derivatives is an integral part of coke-oven operations at many plants. There was no change in the number of producers processing crude tar, and about the same percentage of tar was processed in 1968 as in 1967. With crude light oil, however, the greatest proportion of the output was sold for processing outside the producing plants. This marked change in the processing or refining of crude light oil started in the early 1960's, when a few of the producing plants started to sell their output because their processing equipment was not able to produce the high-purity derivatives required by some of the large markets.

Price quotations on oven foundry coke as published in various trade journals increased $2.50 per ton during 1968. Beehive coke prices at some locations increased $1.20 per ton. Prices on coal-chemical materials changed only slightly during the year. There was no change in ammonium sulfate, but naphthalene prices increased approximately 1½ cents per pound. Prices on the principal light oil derivatives benzene and xylene decreased one to 2 cents per gallon. Toulene prices increased approximately 1½ cents per gallon.

Foreign trade in coke was relatively small, but exports were 11.5 percent greater than in 1967. This was due entirely to a more than doubling of exports to Mexico. Imports were insignificant and were only about one-tenth as large as exports.

The total value of all coals carbonized was $909 million, and the total value of carbonization products was $1,470 million or 61.7 percent more than the value of the coal. The value of coke and breeze represented 81 percent of the value of all coke oven products.

COKE AND BREEZE

DOMESTIC PRODUCTION

Production of coke, which had been increasing in the second half of 1967, continued to increase in the first half of 1968. From January through June, daily average output ranged between 183,000 and 187,000 tons. This high rate of coke production occurred as a result of a large buildup in stocks by iron and steel producers in anticipation of a steelworkers strike in June. The strike was averted, and steel producers, with large inventories, sharply curtailed their purchases of iron ore and coke. Consequently, the daily average output of 185,000 tons in June fell to a low of 153,000 tons in October. Production turned upward in November and gained further in December. The daily average output of coke in these months was 157,000 and 167,000 tons, respectively.

The terms "merchant" and "furnace" in this report apply only to oven-coke plants. Furnace plants are owned by, or affiliated with, iron and steel companies that produce coke mainly for use in their own blast furnaces. Merchant plants include those that manufacture metallurgical, industrial, and residential-heating grades of coke for sale on the open market; those associated with chemical companies or gas utilities; and those affiliated with local ironworks that consume only a small part of their output in affiliated blast furnaces. Both merchant and furnace plants shared in the reduced output primarily because of lessened demands from all markets. Oven-coke output supplied by merchant plants continued to decline in 1968, their share of the output amounting to less than 10 percent. Tables 6 and 7 show production of oven coke by merchant and furnace plants in 1968.

Coke was again produced in 21 States in 1968, with 93 percent manufactured in 15 States east of the Mississippi River. Since the nationwide pattern of supply has not changed to any marked degree in the past decade, the relative proportions supplied by the individual States have remained relatively static. The bulk of coke output in 1968, as always, was centered in the highly industrialized States which use coke as blast-furnace fuel for ironmaking.

Pennsylvania continued to be the largest producer, with oven- and beehive-coke output comprising nearly 30 percent of the U.S. total.

Breeze is the small sizes of coke that result from screening and although there is no designated size, usually includes the coke that passes through a ½-inch screen, or in a few instance, a ⅝-inch screen. In past years, this material, which generally has a higher ash and moisture content than the large sizes, has been used principally as boiler fuel at producing plants. Although about 12 percent of the production is still used for this purpose by producers, usage has changed considerably in the past decade and 40 percent of the production in 1968 was used by integrated producers for sintering iron ores.

The yield of breeze at oven-coke plants ranged between 7.26 percent for plants in Minnesota and Wisconsin to 3.10 percent for plants in Pennsylvania but averaged 4.53 percent for the industry. Most beehive plants do not recover breeze, but the average yield for the plants that did report production was 6.87 percent.

Table 9 shows the production and disposal of breeze in 1968 by State; table 10 shows the quantities of breeze used by producers according to major end use and the quantities and values of the breeze sold in 1968 and in prior years and base periods.

CONSUMPTION AND SALES

The United States consumed 62.4 million short tons of coke in 1968. This apparent consumption, (total production plus imports, minus exports and changes in producers' stocks) was 1.4 percent higher than in 1967 but nearly 6 percent less than in 1966 and 20 percent less than the record high of 1951.

Although total coke consumption increased 866,000 tons in 1968, blast furnace consumption of coke decreased 300,000 tons compared with that in 1967. Pig iron production, however, was 1.7 million tons higher in 1968 than in 1967. Blast furnaces required 20 pounds less coke in 1968 than in 1967 to produce 1 ton of pig iron. This improvement in the coke rate, which has occurred each year since 1951 with the exception of 1965, is the largest single factor in the general decline in coke consumption in recent years. The continuing downward trend in coke rates is attributed mainly to improved burdens (coke and iron ore) and advanced operating techniques, such as higher blast temperatures, fuel injection, and oxygen enrichment of the blast. The ultimate effect of these technologic improvements on the coke industry can be illustrated by the hypothetical case that if blast furnaces in 1968 operated at 1951 rates, the 89.3 million tons of pig iron and ferroalloys produced in 1968 would have required 83.6 million tons of coke rather than the 56.7 million tons actually consumed.

All other consuming groups used more coke in 1968. Sales to all other industrial plants increased more than sales to other categories, nearly 60 percent. Sales to the residential heating market increased slightly in 1968. However, fuel oil and natural gas have virtually replaced coke for this purpose, and the quantity of coke so used will probably soon be negligible.

Data on coke consumption are shown in table 11; data on coke rates are shown in table 12.

Tables 13 and 14 summarize, by major end use, the disposal of oven and beehive coke in 1968. Furnace oven-coke plants supplied 90 percent of the 62.5 million tons of oven and beehive coke distributed. Ninety-six percent of the coke distributed by furnace plants was consumed in integrated and affiliated blast furnaces, an additional 1 percent was used for other purposes, and the remaining 3 percent was marketed, chiefly to blast furnaces and other industrial plants but with small quantities going also to foundries and for residential heating.

Merchant coke plants distributed nearly 6 million tons of coke in 1968, 94 percent of which was placed on the commercial market. Principal markets were blast-furnace operations without coke facilities, independent gray-iron foundries, nonferrous smelters, and chemical plants. Of the 5.8

million tons of oven coke sold by merchant plants in 1968, 40 percent was shipped to blast furnaces, 46 percent to foundries, and 12 percent to other industrial plants; the remaining 2 percent was sold for residential heating. Only 4 percent of the total coke distributed by merchant plants was retained for use by the producers.

Less than 1.2 percent of the coke distributed in 1968 came from beehive plants. Seventy-four percent of the beehive shipments went for use in blast furnaces. Most of the remainder went to other industrial plants. These were mainly chemical plants that used the coke to produce calcium carbide and elemental phosphorus. Minor quantities were used also in foundries and for residential heating. Coke was produced in or received by all States except Alaska, Hawaii, and the District of Columbia in 1968. A total of 61.9 million tons of coke was distributed domestically. This was approximately 200,000 tons higher than shipments in 1967. Shipments to blast furnaces fell by 500,000 tons, but shipments to foundries and to all other industrial plants increased by more than 600,000 tons.

Twenty-one States consumed 56.4 million tons of blast-furnace coke. Pennsylvania, Ohio, Indiana, Illinois, Michigan, New York, Maryland, Alabama, and West Virginia together received 91 percent of the total. Most blast-furnace installations are integrated with coke ovens, and blast-furnace coke generally moves only short distances, usually by conveyor belt or company railroad within the producing establishment. Coke so restricted in its movement accounted for 90 percent of the blast-furnace distribution. The remaining 10 percent, was shipped out of the producing State, mainly to affiliated blast furnaces in nearby States.

The chief recipients of foundry-coke shipments were the automotive, farm-machinery, machine-tool, heavy-machinery, railroad, and electrical-equipment industries. Most of these industries are concentrated in the East and Midwest. To reach these markets, foundry coke generally must be shipped long distances by rail. In 1968, the combined consumption of Michigan, Ohio, Alabama, Pennsylvania, Illinois, Indiana, Wisconsin, and New York accounted for 76 percent of the foundry-coke shipments. Lesser quantities were sent to 37 other States.

Less than 4 percent of the total coke distributed was utilized for miscellaneous industrial applications by, among others, nonferrous smelters, alkali plants, and chemical plants that manufacture calcium carbide and elemental phosphorus. Leading consumers of this classification of coke were, in the order named, Ohio, Illinois, Pennsylvania, Idaho and Michigan. Together, these 5 States consumed nearly two-thirds of the total other-industrial markets.

The quantity of coke used for residential heating in 1968 declined 26 percent from the 1967 level. Although 26 States used coke for this purpose, the quantity sent to each was so small that the total distributed was only 63,000 tons. Twelve States consumed less than 500 tons each, and only four States used more than 5,000 tons. Distribution of oven and beehive coke and breeze, by major end use and final destination, are shown in table 15.

STOCKS

Coke stockpiled at producers' plants decreased moderately in quantity in the first half of 1968, and then increased rapidly each month thereafter as blast iron production fell sharply. Stocks on hand at the close of the year exceeded those of December 31, 1967, by nearly 10 percent and the 6.0 million tons of coke on hand at the end of the year represented an alltime high. Data on stocks are shown in tables 16 and 17.

Furnace plants ended the year with 5.6 million tons of coke on hand. Merchant plants had coke stocks of 348,000 tons. In terms of days supply, furnace plants had a supply equivalent to 38 days of production at the December rate, while merchant plants had 22 days of coke supply. Stocks at merchant plants were composed of 6 percent blast-furnace coke; 49 percent foundry coke; and 45 percent, other grades.

Stocks of coke at beehive plants varied only slightly from those in the preceding year and were insignificant.

Coke breeze stocks were almost identical to those of 1967. Producers had a 192,000-ton supply at merchant plants and 820,000 tons at furnace plants.

VALUE AND PRICE

Average receipts for commercial sales f.o.b. plant of the different grades of coke as reported by producers are shown in table 18. Receipts for sales of oven coke in 1968 averaged $22.00 per ton, a decrease of $0.67. This was due to a $1.19 decrease in the price of oven coke to the industrial plant sector. The average value of blast-furnace plant receipts increased 11 cents per ton. Foundry prices were on the average 3 cents higher and residential heating prices increased 61 cents per ton. Receipts for total beehive coke sales were 3 cents below those of 1967. This overall decrease in receipts was due solely to $5.50 per ton decrease in the average price per ton of coke sold to foundries.

The large variance in price for blast-furnace and foundry oven coke was attributed principally to the lower yields obtained in producing foundry coke, and to larger minimum sizes required to meet foundry-coke specifications. The differences in f.o.b. prices of oven and beehive foundry coke were due largely to transportation costs for coal and/or coke.

FOREIGN TRADE

U.S. exports of coke increased nearly 12 percent from those of the preceding year. This increase was the result of a doubling in the amount of coke shipped to Mexico and Venezuela. The increase in exports to these countries more than offset a 192,000-ton decline in exports to Canada. Mexico replaced Canada as the leading export market, absorbing nearly 44 percent of the foreign consumption of U.S. coke. The combined total of shipments to Mexico, Canada, and Venezuela accounted for 93 percent of total coke exports.

More than three-fourths of the coke exports were through the Buffalo, N.Y., Detroit, Mich., and Laredo, Tex., customs districts. Each of these ports handled well in excess of 100,000 tons. Table 19 shows exports of coke by country and customs district for 1966, 1967, and 1968. The quantity shown is substantially larger than that reported by producers and shown in table 15 because there were additional shipments to foreign countries by export firms.

The United States imported 94,000 tons of coke. Almost twice this tonnage was produced domestically in a single day. This imported coke had a negligible bearing on the general nationwide market and was significant only in certain local areas, such as the Northwest, which are far removed from sources of coke production.

Ninety-six percent of the coke imported for consumption in 1968 originated in Canada and was produced in the Province of British Columbia. This coke was used mainly in nonferrous smelters and enters the United States through the Great Falls, Mont., customs district. Three percent of the imported coke came from West Germany, and the remaining 1 percent, from France and the Netherlands.

Table 20 shows imports of coke for 1968 and the two immediately preceding years, by country and customs district.

WORLD PRODUCTION

World production of metallurgical coke in 1968 was estimated at 335 million tons, an apparent decrease of 9 percent from the estimated 1967 output. This decrease, however is attributable entirely to the exclusion of the coke production of 17 countries for which data were not available. If the 1967 production total excluded the output of the countries for which 1968 data were not available, world production in 1968 comparatively increased 2.4 percent.

Europe maintained the lead in world production with 54 percent of the output. This share would be higher if data for Czechoslovakia, East Germany, and Poland were available. These countries combined produced 30 million tons of coke in 1967.

Output of coke and breeze in the Soviet Union, the world's largest producer, was estimated at 78 million tons, about two-fifths of the European total and nearly one-fourth of the world output. This was an increase of 2 percent over the 1967 production and a record output of the U.S.S.R. Although Soviet production exceeds that of the United States, the actual difference in outputs of the two countries was 10.6 million tons rather than 14.6 million tons as reflected in table 21, because the U.S. production figure does not include 4 million tons of breeze produced in 1968.

The United States with 19 percent of the world output ranked second and West Germany, with 12 percent, ranked third. The United States had a 1.4-percent production decrease, while West Germany's output was nearly 3 percent above that of 1967.

Other leading coke-producing countries in order of output were Japan, the United Kingdom, mainland China, France, and India. Highest production increases of 15, 13, and 6 percent, respectively—were recorded in mainland China, Japan, and New Zealand. Production in other countries did not change appreciably.

COAL CHEMICALS

The term "coal chemicals" refers to the chemical materials recovered from the volatile matter released during carbonization. Normally, three basic materials—ammonia, tar, and light oil—are recovered at oven-coke plants through a series of complex condensation and absorption processes. The remaining material, which is rich in hydrogen and methane, is called coke-oven gas. Except for ammonia, which is recovered as an aqueous solution or converted to a salt and sold as produced, the basic materials are in most instances further processed to yield a number of primary organic chemicals or chemical mixtures of which the most important are benzene, toluene, xylene, solvent naphtha, crude chemical oil, creosote oil, pitch, and pyridine. Although most oven-coke plants in the United States are equipped to process tar and light oil, the extent to which individual plants produce the various products depends upon economic conditions and a number of other factors.

Yields of the basic, as well as the primary, chemicals vary somewhat with the kind of coals carbonized, carbonizing temperatures, and operating techniques and equipment, but approximately 315 pounds of coke-oven gas, 90 pounds of tar, 20 pounds of light oil, and 5 pounds of ammonia are recovered for each ton of coal carbonized. In standard units of measure these quantities amount to about 10,500 cubic feet of coke-oven gas, 10 gallons of tar, and 3 gallons of light oil. Ammonia is recovered as ammonium sulfate at most operations, and the yield per ton of coal is approximately 20 pounds. Data on production and sales of basic chemical materials and derivatives at oven-coke plants in 1968 are shown in table 33.

Table 34 shows the heating value and coal equivalent of products other than coke produced at oven-coke plants. Although the quantities vary from year to year, most of the changes were due to differences in the amount of coal carbonized, rather than fluctuations in yields. In terms of heating value, the products, not including coke, recovered in 1968 were roughly equivalent to the heating value of about one-fourth of the coal carbonized in slot ovens. Table 35 shows average values for the chemicals and surplus gas used and sold, compared with the unit values of the coke and breeze produced, from each ton of coal carbonized.

COKE-OVEN GAS

Coke-oven gas is one of the primary coproducts recovered in the carbonization of coal in slot ovens. After tar, ammonia, and light oil have been removed from the gaseous streams, coke-oven gas remains as the final product. Because it has a high calorific value producers use most of it as fuel for heating coke ovens and other steel- and allied-plant furnaces. Small quantities are also sold for distribution through city mains and other industrial uses.

Generally, between 9,300 and 11,000 cubic feet of gas is produced for each ton of coal carbonized at high temperatures in slot ovens. This equals from 14 to 16 percent of the weight of the coals. In 1968, the yield of gas was 10,251 cubic feet per ton of coal, a decrease of 2 percent from the 1967 yield, due largely to lower yields in the far Western States.

About 36 percent of the output was used at the plants to heat coke ovens. Gas used otherwise is called surplus gas and was used by producers to fire boilers, transferred to steel or allied plants to heat open-hearth and other metallurgical furnaces, sold for industrial use or distributed through city mains. A small part of the production was wasted because storage facilities at most plants are limited and the gas was burned in the atmosphere when production exceeded demand.

Furnace plants consumed almost all of their own surplus gas, mostly in steel and allied plants. Only 30 percent of the surplus gas at merchant plants was used by the producers. The rest, except for the small amount wasted, was sold commercially for distribution through city mains and for industrial use. The bulk of the furnace-plant gas sales were to industrial plants. Table 39 shows the quantities of various gases used to heat ovens in each State and the total gas consumption, in terms of coke-oven gas equivalent. Coke-oven gas was the principal fuel used for heating slot ovens, but blast-furnace gas, a mixture of coke-oven and blast-furnace gases, and natural gas were also used. Over 400 billion cubic feet of coke-oven gas equivalent was so consumed, of which 77 percent was coke-oven gas; 22 percent was blast-furnace gas; and the remainder was natural gas and producer gas.

Surplus coke-oven gas used and sold in 1968 was valued at $133 million. This 3.5 percent decrease from the 1967 value was due to the overall lower quantity, as the average value per thousand cubic feet actually increased slightly. No value is reported by producers for coke-oven gas used to heat coke ovens, but applying the average value of $0.232 per thousand cubic feet reported for surplus gas to the gas used for underfiring, the total value of all coke-oven gas used and sold in 1968 would be $210 million. This value is equivalent to nearly one-fourth of the total value of the coal carbonized.

COKE-OVEN AMMONIA

Coal carbonized at high temperatures releases nitrogen, which oven-coke operators recover as either ammonia liquor, a weak solution of ammonia (about 7 grams per liter of solution), or as a crystallized solid (ammonium sulfate and diammonium and monoammonium phosphate). This ammonia must be removed prior to further processing of the gas because it would otherwise form corrosive salts which would damage equipment or if allowed to be released as a waste material would create stream pollution problems.

Most of the coke-oven ammonia is reacted with sulfuric acid to form ammonium sulfate. In 1968, 49 plants used 91 percent of the total ammonia recovered to produce 670,000 tons of ammonium sulfate, and another 4 percent was treated with phosphoric acid to produce 31,000 tons of diammonium phosphate at three plants. Nine plants recovered ammonia liquor, and six recovered no ammonia products at all.

Table 40 shows production and sales of ammonia products and yields in 1968 in terms of sulfate equivalent. Compared with 1967, the yield of ammonia declined 7 percent, and total output also fell 7 percent.

Sales of ammonium sulfate decreased 6 percent and ammonia liquor sales were about the same as in 1967. The average value per ton, f.o.b. plant of ammonium sulfate decreased $5.93 per ton to $20.94, and the average plant values of diammonium phosphate and ammonia liquor, decreased $0.28 per ton and $6.38 per ton, respectively. The total value of all ammonia products sold was $17 million, equivalent to 7 percent of the total value of all coal-chemical materials sold.

COAL TAR AND DERIVATIVES

Crude coal tar is a black, viscous mixture of complex organic compounds that condense from the volatile matter when it is cooled. Most of the tar is recovered in collecting mains at the ovens when the gas is cooled by spraying with ammonia liquor; the remainder is recovered principally from the primary coolers when the gas undergoes further cooling.

All oven-coke plants produce tar. However, yields of tar vary widely among plants; in 1968 they ranged from 3.75 to 11.30 gallons per ton of coal carbonized, and averaged 8.45 gallons. Generally, from 4 to 5 percent of the weight of the coals carbonized is recovered as tar. High-volatile coals evolve a larger percentage of tar; hence, California, Colorado, Utah, West Virginia, and Pennsylvania, which used the most high-volatile coal in their blends, had the highest tar yields. Conversely, plants using higher percentages of low- and medium-volatile coals and anthracite, such as those mainly producing foundry coke, had the lowest yields.

Production of coal tar at oven-coke plants in 1968 decreased 2.5 percent from 1967 principally because less coal was carbonized. The average yield of tar decreased slightly, 8.45 gallons per ton of coal as compared with the yield of 8.53 gallons in 1967. Table 41 shows the quantities of tar produced, used by producers, sold, and in stock in the various States at the end of 1968.

Coke-plant operators used 54 percent of the tar produced in 1968. Of this quantity, 73 percent was processed (refined or "topped"), 26 percent underwent no processing and was burned for fuel, and 1 percent was used for miscellaneous purposes, such as tarring ingots, road materials, and tar paints. The remaining 46 percent of the production was sold, principally to tar-distilling plants which refined it to produce many tar derivatives.

Of the 13 coke plants that processed tar in 1968, seven topped their tar. In so doing, the low-boiling distillate fraction, consisting mainly of tar acids, bases, and naphthalenes, is separated from the crude tar. The residue, or soft pitch, is usually burned as fuel. Furnace plants in particular benefit from this procedure because they can sell the distillate and retain the pitch for use as fuel in open-hearth furnaces. This reduces the amount of other fuels that normally have to be purchased. However, the relative quantities of tar topped and burned, as well as the quantities sold, depend upon a number of economic factors, such as the availability and current market prices of tar, tar distillates, and other substitute fuels. All of the merchant-plant tar production was sold because these plants have no use for the pitch which makes up the bulk of the products recovered through topping.

The majority of the plants that processed tar in 1968 recovered only crude chemical oil and a residual tar or soft pitch. However, some of the larger plants, recovered a number of other tar derivatives, including creosote oil, cresylic acid, cresols, naphthalene, phenol, pyridine, and medium and hard pitch. Statistics on some of these products could not be shown in this report, but the data were transmitted to the U.S. Tariff Commission which published them, along with similar data from tar distillers and petroleum refiners, in monthly and annual reports on synthetic organic chemicals.

CRUDE LIGHT OIL AND DERIVATIVES

Light oil is a light-colored liquid, composed of a number of aromatic hydrocarbons, that is extracted from the gas after tar, ammonia, and, in some instances, naphthalene, have been removed. Crude tar also contains a small amount of light oil, but this usually is not recovered by coke plants. Virtually all light oil produced at coke plants is recovered by an absorption process in which the gas is sprayed with a higher boiling petroleum oil as the gas stream is channeled through absorption towers. After recovery, light oil is separated from the absorption oil by direct steam distillation. Approximately 3 gallons of light oil, equal to 1 percent of the weight of the coal, is recovered for each ton of coal carbonized. Yields vary, of course, with the kinds of coals carbonized and with operating conditions, but an average of 2.65 gallons of light oil was recovered at the plants that extracted light oil in 1968. Most plants recover light oil, but a few plants which find it uneconomical to remove the light oil, leave it in the gas to be burned as fuel. Yields per ton of coal increased slightly at merchant plants, but decreased by nearly three-tenths of a gallon at furnace plants.

Producers sold 39 percent of their output in 1968. The large increase in light-oil sales in recent years is attributed principally to the inability of some plants to produce derivatives, particularly benzene, that meet the more rigid specifications established for these products. Such plants sell light oil to petroleum-refining companies which process it along with petroleum fractions into benzene and a number of other chemical intermediates. Data on light oil and total derived products produced and sold in the various States are shown in table 42.

In the older light-oil-refining facilities at coke plants light oil is refined by fractional distillation at atmospheric pressures, but in plants built in recent years, catalytic-pressure refining is employed to produce benzene, toluene, xylene, and solvent naphtha. As with other coal-chemical materials, yields vary somewhat, but approximately 85 percent of the light oil processed is recovered as salable products. Average yields of light-oil derivatives increased in 1968. Average yields for 1968 and prior years are shown in table 43.

Table 44 shows the quantities of the various grades of benzene and toluene produced at coke plants, while table 45 shows the principal light-oil derivatives produced and sold and yields of the various products by State.

COKING COALS

Quantity and Value of Coal Carbonized.—The carbonization of bituminous coal for coke production is currently the second largest end use of this fuel. Only electric utilities, whose annual consumption of bituminous coal generally absorbs about half of the production, ranks higher in usage. In 1968 coke producers charged 91 million tons of bituminous coal, one-sixth of the total bituminous coal produced, into coke ovens. An additional 532,000 tons of anthracite was blended with bituminous coal at oven-coke plants and carbonized, chiefly to produce foundry coke.

The average value per ton for all coals carbonized at oven-coke plants was $10.01 compared with an average value of $5.71 per ton for the coal carbonized at beehive ovens. The difference in value was attributed mainly to transportation charges for coal shipped to oven plants, as virtually all beehive plants are located at the mines where they obtain their coal. In some instances transportation charges exceed the value of the coal at the mine, and this partially accounts for the high values of coals used at plants in the Western States, most of which receive shipments of low-volatile coals from the East.

The overall average value per ton of the coals carbonized at both oven- and beehive-coke plants was 1 cent less than in 1967. While coal costs increased in most States, they did not increase sufficiently to offset the more sizable cost decreases of coal in Kentucky and Pennsylvania.

An overall average of 1.43 tons of coal, valued at $14.33, was required for each ton of oven coke produced in 1968. Beehive ovens required an average of 1.64 tons of coal per ton of coke production, but coal costs averaged only $9.34 per ton of coke because of the lower value of the coal delivered to beehive ovens.

Tables 22–25 present data on the coals carbonized at oven and beehive plants.

Blending.—The production of high-quality coke requires the use of coal with certain special characteristics. Since all of the desired properties are not inherent in an individual coal, it becomes necessary to blend coals, exploiting the most favorable traits of each in a carefully balanced mixture. Thus, coals are selected and combined in order to improve the chemical and physical properties of the coke, control the pressure developed in slot ovens during carbonization, regulate the yield of products, and broaden the use of inferior coals. The usual procedure followed is to blend relatively small proportions of low-volatile coal with high-volatile coal. The exclusive use of high-volatile coals would result in a weaker coke and lower yields. The addition of low-volatile coals improves the yield and the physical structure of the coke. However, restrictions on the proportions of low-volatile coals used as necessary because they are highly expanding and, if used alone or in large proportions in the coal mix, would damage the oven walls when coke was discharged from the ovens. Some plants add medium-volatile coals or other materials, such as anthracite or coal-tar pitch, to their high- and low-volatile coals. The addition of medium-volatile coals can regulate the volatile matter in a mix to the desired content, while anthracite and coal-tar pitch are used to impart special properties to the resulting coke.

Some coals are unsuitable for the production of coke because they contain excessive amounts of sulfur. These coals still may be utilized to some extent if they are blended with low-sulfur coals. This is permissible if the low-sulfur coals compensate for the excess in the high-sulfur coals, maintaining the total sulfur at a level no higher than normally used for the production of coke of high quality.

The relative quantities of high-, medium-, and low-volatile coals blended by coke producers are fairly constant, with little variation from year to year at individual plants. From plant to plant, however, a wide range of blends is employed. In 1968, high-volatile coals were carbonized most extensively in West Virginia and the Far West, while Minnesota and Wisconsin used fairly large percentages of low-volatile coals. The largest proportions of low-volatile coals were used at merchant plants to improve the strength of the foundry coke which makes up the bulk of their output. Table 26 shows the average volatile-matter content of the coals carbonized at oven-coke plants, and table 27 shows the volatile-matter content of the coals received by oven-coke plants in the various States.

Sources.—Although 22 States produced bituminous coal (excluding lignite) in 1968, only 10 shipped coal to coke plants. Of this number, five States (Alabama, Kentucky, Pennsylvania, Virginia, and West Virginia) supplied 91 percent of the total. The remainder was supplied by Colorado, Illinois, New Mexico, Oklahoma, and Utah.

Of the coals received by oven-coke plants, 39 percent was produced in West Virginia and 29 percent in Pennsylvania. West Virginia shipments were principally low-volatile coals from McDowell County, and high-volatile coals from Logan, Marion, and Fayette Counties. Pennsylvania shipments were principally high-volatile coals from Washington, Greene, and Allegheny Counties, and low-volatile coals from Cambria County.

Illinois supplied more than 1.5 million tons of high-volatile coal to coke plants in Illinois and Indiana. This coal was blended with larger proportions of high-rank Eastern coals that were shipped principally from Kentucky, Virginia, and West Virginia.

Most of the coals carbonized in California, Colorado, and Utah were produced in the latter two Western States. In most instances, plants in the Western States also received shipments of West Virginia low-volatile coals that were used for blending. Tables 28 and 29 show the origin of the coals received by oven-coke plants in 1968.

The coke industry received 58 percent of its coal from company owned or affiliated mines in 1968. Most of the captive mines are owned by iron- and steel-producing companies. In 1968, 60.3 percent of the total coal received by furnace plants was captive. Merchant plants received 34.4 percent of their coal from company owned or affiliated sources. Table 30 shows the quantities and percentages of captive coal received by oven-coke plants for 1968 and several prior years.

Stocks.—Producer's month-end stocks of bituminous coal at oven-coke plants, which averaged 11 million tons during the first 6 months of the year, began declining in June and at the end of December were 13 percent lower than at the end of 1967. Bituminous coal stocks at merchant plants were sufficient for 50 days supply at the December rate of production; furnace plants had coal sufficient for 40 days supply.

Stocks of anthracite amounted to 154,000 tons at the end of 1968, a decrease of 3,000 tons from those of 1967. Tables 31 and 32 show month-end stocks of bituminous coal and anthracite at oven coke-plants.

TECHNOLOGY

The major emphasis of research and development work on coal carbonization in 1968 was directed toward reducing carbonizing costs, improving coke quality and increasing oven productivity. More intensive efforts were made to develop equipment and establish techniques to reduce atmospheric and stream pollution. Work continued on developing methods or processes of producing metallurgical coke from noncoking coals.

One of the more important innovations for reducing coke production costs in recent years has been the installation of high-capacity or large ovens. These ovens range in height from about 16.5 to 20 feet and average about 60 percent greater in capacity than the usual 13-foot-high ovens. These ovens incorporate several novel features, such as high-conductivity oven brick, oven walls that decrease in thickness from the pusher side to the coke side and a readily controllable multilevel burning system.

The largest construction program for these large capacity ovens is one by Bethlehem Steel Corporation at its Lackawanna, N.Y., plant. The 76 new ovens will be one-third taller than any of the 535 coke ovens now operating at the plant.

Operating experience with high ovens as of 1968, has demonstrated that—

1. Tall ovens can be operated at a fast coking rate; that is 1.2 inches per hour with both coke oven and blast furnace gas underfiring.
2. Operating equipment (pusher machine, etc.) for the tall ovens has given satisfactory service.
3. The faster coking rates on the tall ovens result in smaller size coke being produced.
4. Reduction in costs per ton of coke produced is achieved through increased productivity.

Considerable research in the control of water pollution at coke plants was conducted during the year. Initial steps were taken by Interlake Steel Corporation in its goal of a total recirculation system. A closed recirculating system was installed at the coke quenching operation. The company also installed a closed recirculating system and naphthalene removal system at the final coolers.

Bureau of Mines research during 1968 was directed toward appraising the extent and availability of metallurgical quality coals in the United States in conjunction with surveys of deposits of low-sulfur coals.

The Bureau also intensified its efforts to obtain a more uniform quality of coke from Western coals by using different types of blending operations. The Bureau's pilot-plant research of carbonizing coal from the low-sulfur areas of southern Illinois proved that these coals blended with eastern coals provide a satisfactory metallurgical coke.

Table 2.—Statistical summary of the coke industry in the United States in 1968[1]

	Slot ovens	Beehive ovens	Total
Coke produced:			
At merchant plants, thousand short tons	5,879	(2)	(2)
At furnace plants[3], do.	56,999	(2)	(2)
Total, do.	62,878	775	63,653
Breeze produced, do.	4,074	25	4,099
Coal carbonized:			
Bituminous:			
Thousand short tons	89,497	1,268	90,765
Value (thousands)	$895,097	$7,237	$902,334
Average per ton	$10.00	$5.71	$9.94
Anthracite:			
Thousand short tons	532	--------	532
Value (thousands)	$6,198	--------	$6,198
Average per ton	$11.65	--------	$11.65
Total:			
Thousand short tons	90,029	1,268	91,297
Value (thousands)	$901,295	$7,237	$908,532
Average per ton	$10.01	$5.71	$9.95
Average yield in percent of total coal carbonized:			
Coke	69.84	61.12	69.79
Breeze (at plants actually recovering)	4.53	6.87	4.54
Coke used by producing companies:			
In blast furnaces:			
Thousand short tons	53,312	--------	53,312
Value (thousands)	$944,527	--------	$944,527
In foundries:			
Thousand short tons	383	--------	383
Value (thousands)	$13,564	--------	$13,564
For other industrial uses:			
Thousand short tons	592	--------	592
Value (thousands)	$5,496	--------	$5,496
Breeze used by producing companies:			
In steam plants:			
Thousand short tons	508	--------	508
Value (thousands)	$3,021	--------	$3,021
In agglomerating plants:			
Thousand short tons	1,634	--------	1,634
Value (thousands)	$11,594	--------	$11,594
For other industrial uses:			
Thousand short tons	589	--------	589
Value (thousands)	$4,430	--------	$4,430
Coke sold (commercial sales):			
To blast furnaces:			
Thousand short tons	3,345	570	3,915
Value (thousands)	$54,837	$8,636	$63,473
Average per ton	$16.29	$15.15	$16.21
To foundries:			
Thousand short tons	2,934	30	2,964
Value (thousands)	$95,127	$212	$95,339
Average per ton	$32.43	$6.80	$32.16
To other industrial plants:			
Thousand short tons	1,883	174	2,057
Value (thousands)	$30,071	$2,581	$32,652
Average per ton	$15.97	$14.83	$15.87
For residential heating:			
Thousand short tons	114	(4)	114
Value (thousands)	$2,041	(4)	$2,041
Average per ton	$17.96	(4)	$17.96
Breeze sold (commercial sales):			
Thousand short tons	1,338	26	1,364
Value (thousands)	$10,844	$202	$11,046
Average per ton	$8.10	$7.77	$8.10

See footnotes at end of table.

Table 2.—Statistical summary of the coke industry in the United States in 1968[1]—Continued

	Slot ovens	Beehive ovens	Total
Coal-chemical materials produced:			
Crude tar:			
Thousand gallons	760,761	--------	760,761
Gallons per ton of coal	8.45	--------	8.45
Ammonia:[5]			
Thousand short tons	768	--------	768
Pounds per ton of coal	17.06	--------	17.06
Crude light oil:			
Thousand gallons	238,887	--------	238,887
Gallons per ton of coal	2.65	--------	2.65
Gas:			
Million cubic feet	922,910	--------	922,910
Thousand cubic feet per ton of coal	10.25	--------	10.25
Percent burned in coking process	35.96	--------	35.96
Percent surplus used or sold	62.35	--------	62.35
Percent wasted	1.69	--------	1.69
Value of coal-chemical materials used or sold:			
Crude tar and derivatives:			
Used ... thousands	$28,015	--------	$28,015
Sold ... do	$63,765	--------	$63,765
Ammonia products [6] ... do	$17,505	--------	$17,505
Crude light oil and derivatives [7] ... do	$38,479	--------	$38,479
Surplus gas ... do	$133,486	--------	$133,486

[1] Data may not add to totals shown because of independent rounding.
[2] Not separately recorded.
[3] Plants associated with iron-blast furnaces.
[4] Combined with coke sold "To foundries" to avoid disclosing individual company data.
[5] In terms of sulfate equivalent.
[6] Includes ammonium sulfate, ammonia liquor (NH_3 content), and diammonium phosphate.
[7] Includes intermediate light oil.

Table 3.—Summary of oven-coke operations in the United States in 1968, by States[1]

State	Plants in existence Dec. 31 [2]	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Alabama	7	7,710	70.84	5,462
California, Colorado, Utah	3	5,022	63.19	3,174
Connecticut, Maryland, New Jersey, New York	6	10,896	69.75	7,599
Illinois	5	3,083	67.28	2,074
Indiana	5	11,641	70.00	8,144
Kentucky, Missouri, Tennessee, Texas	5	2,898	69.00	2,000
Michigan	3	4,986	73.89	3,683
Minnesota and Wisconsin	3	1,090	77.45	844
Ohio	12	12,000	70.23	8,428
Pennsylvania	12	25,764	70.29	18,110
West Virginia	3	4,939	68.04	3,360
Total in 1968	64	90,029	69.84	62,878
At merchant plants	16	8,259	71.18	5,879
At furnace plants	48	81,770	69.71	56,999
Total 1967	66	91,428	69.75	63,775

[1] Data may not add to totals shown because of independent rounding.
[2] Excludes plants retired permanently during year.

Table 4.—Summary of beehive-coke operations in the United States in 1968, by States[1]

State	Plants in existence Dec. 31[2]	Coal carbonized (thousand short tons)	Yield of coke from coal (percent)	Coke produced (thousand short tons)
Pennsylvania	4	585	60.77	355
Kentucky, Virginia, West Virginia	3	683	61.42	419
Total:				
1968	7	1,268	61.12	775
1967	16	1,372	58.72	806

[1] Data may not add to totals shown because of independent rounding.
[2] Excludes plants retired permanently during year.

Table 5.—Production of oven and beehive coke in the United States, by months[1] [2]

(Thousand short tons)

Month	1967		1968	
	Total	Daily average	Total	Daily average
OVEN COKE				
January	5,457	176	5,602	181
February	5,000	172	5,352	185
March	5,557	179	5,686	183
April	5,316	177	5,529	184
May	5,398	174	5,692	184
June	5,102	170	5,468	182
July	5,108	165	5,453	176
August	5,209	168	5,046	163
September	5,155	172	4,633	154
October	5,413	175	4,613	149
November	5,413	180	4,669	156
December	5,647	182	5,137	163
Total	63,775	174	62,878	172
BEEHIVE COKE				
January	116	4	74	2
February	89	3	69	2
March	60	2	79	3
April	57	2	81	3
May	56	2	82	3
June	53	2	72	2
July	46	1	64	2
August	58	2	60	2
September	54	2	51	2
October	72	2	46	1
November	72	2	46	2
December	73	2	49	2
Total	806	2	775	2
TOTAL				
January	5,573	180	5,676	183
February	5,089	175	5,421	185
March	5,616	181	5,765	186
April	5,874	179	5,610	187
May	5,455	176	5,774	186
June	5,154	172	5,540	185
July	5,153	166	5,517	178
August	5,267	170	5,106	165
September	5,209	174	4,685	156
October	5,485	177	4,660	153
November	5,486	183	4,715	157
December	5,720	185	5,186	167
Total	64,580	176	63,653	174

[1] Data may not add to totals shown because of independent rounding.
[2] Daily average calculated by dividing monthly production by number of days in month.

Table 6.—Production of oven coke in the United States, by type of plant[1]

(Thousand short tons)

Month	1967		1968	
	Merchant plants	Furnace plants	Merchant plants	Furnace plants
PRODUCTION				
January	558	4,899	524	5,077
February	495	4,505	510	4,842
March	545	5,011	527	5,159
April	517	4,799	508	5,021
May	528	4,870	515	5,177
June	511	4,591	516	4,952
July	499	4,608	504	4,948
August	511	4,697	454	4,591
September	490	4,665	417	4,216
October	521	4,892	443	4,171
November	515	4,898	462	4,206
December	528	5,119	499	4,638
Total	6,220	57,555	5,879	56,999
DAILY AVERAGE				
January	18	158	17	164
February	17	155	18	167
March	18	162	17	166
April	17	160	17	167
May	17	157	17	167
June	17	153	17	165
July	16	149	16	160
August	16	152	15	148
September	16	156	14	141
October	17	158	14	136
November	17	163	15	140
December	17	165	16	150
Average for year	17	157	16	156

[1] Data may not add to totals shown because of independent rounding.

Table 7.—Production of oven coke and number of plants in the United States, by type of plant

Year	Number of active plants[1]		Coke produced (thousand short tons)		Percent of production	
	Merchant plants	Furnace plants	Merchant plants	Furnace plants	Merchant plants	Furnace plants
1964	17	47	6,336	54,573	10.4	89.6
1965	17	48	6,673	58,524	10.2	89.8
1966	16	50	6,377	59,583	9.7	90.3
1967	16	50	6,220	57,555	9.8	90.2
1968	16	48	5,879	56,999	9.4	90.6

[1] Includes plants operating any part of year.

Table 8.—Production of coke in the United States, by States[1]

(Thousand short tons)

State	1967	1968
Oven coke:		
Alabama	5,465	5,462
California, Colorado, Utah	3,076	3,174
Connecticut, Maryland, New Jersey, New York	8,486	7,599
Illinois	2,361	2,074
Indiana	8,293	8,144
Kentucky, Missouri, Tennessee, Texas	2,004	2,000
Michigan	3,309	3,684
Minnesota and Wisconsin	958	844
Ohio	8,081	8,428
Pennsylvania	18,433	18,110
West Virginia	3,309	3,360
Total	63,775	62,878
Beehive coke:		
Pennsylvania	346	355
Virginia	[2] 460	419
Total	806	775
Grand total	64,580	63,653

[1] Data may not add to totals shown because of independent rounding.
[2] Includes Kentucky and West Virginia.

Table 9.—Breeze recovered at coke plants in the United States in 1968, by States[1]

(Thousand short tons and thousand dollars)

State	Yield per ton of coal[2] (percent)	Produced	Used by producers			
			In steam plants		In agglomerating plants	
		Quantity	Quantity	Value	Quantity	Value
Oven coke:						
Alabama	6.27	484	(3)	(3)	128	$786
California, Colorado, Utah	5.57	280	--------	--------	196	1,764
Connecticut, Maryland, New Jersey, New York	5.17	563	273	$1,595	(3)	(3)
Illinois	5.10	157	31	131	81	695
Indiana	5.07	591	(3)	(3)	378	2,200
Kentucky, Missouri, Tennessee, Texas	5.72	166	(3)	(3)	(3)	(3)
Michigan	4.48	223	(3)	(3)	(3)	(3)
Minnesota and Wisconsin	7.26	79	(3)	(3)	(3)	(3)
Ohio	4.20	504	57	493	35	284
Pennsylvania	3.10	798	71	411	579	4,362
West Virginia	4.64	229	(3)	(3)	(3)	(3)
Undistributed	------	--------	76	391	236	1,453
Total 1968	4.53	4,074	508	3,021	1,634	11,545
At merchant plants	------	--------	126	736	--------	--------
At furnace plants	------	--------	382	2,285	1,634	11,545
Total 1967	4.40	4,025	594	3,999	1,695	11,594
Beehive coke:						
Pennsylvania and Virginia	6.87	25	--------	--------	--------	--------
Total 1967[6]	7.01	21	--------	--------	--------	--------

State	Used by producers		Sold		On hand Dec. 31
	For other industrial use				
	Quantity	Value	Quantity	Value	
Oven coke:					
Alabama	28	$226	362	$4,137	19
California, Colorado, Utah	18	142	80	697	27
Connecticut, Maryland, New Jersey, New York	109	1,237	67	463	449
Illinois	15	83	(3)	(3)	25
Indiana	104	708	95	535	42
Kentucky, Missouri, Tennessee, Texas	(3)	(3)	130	1,046	8
Michigan	31	217	62	473	93
Minnesota and Wisconsin	54	238	(3)	(3)	59
Ohio	100	606	333	2,290	121
Pennsylvania	75	507	104	493	167
West Virginia	(3)	(3)	(3)	(3)	1
Undistributed	55	466	106	709	----------
Total 1968	589	4,430	1,338	10,844	[4] 1,012
At merchant plants	102	635	275	2,102	192
At furnace plants	487	3,795	1,063	8,742	820
Total 1967	517	3,393	1,229	10,532	[4] 1,000
Beehive coke:					
Pennsylvania and Virginia,	--------	----------	26	----------	(5)
Total 1967[6]	--------	----------	21	44	(5)

---

[1] Data may not add to totals shown because of independent rounding.
[2] Calculated by dividing production by coal carbonized at plants actually recovering breeze.
[3] Included with "Undistributed" to avoid disclosing individual company data.
[4] Includes some breeze resulting from the screening of coke at blast furnaces.
[5] Less than ½ unit.
[6] Includes Kentucky and West Virginia.

Table 10.—Oven- and beehive-coke breeze used and sold in the United States, by uses

(Thousand short tons)

Year	Used by producers: In steam plants	Used by producers: In agglomerating plants	Used by producers: For other industrial use	Sold	Average value per ton
1964	632	1,764	434	1,116	$7.44
1965	642	1,744	427	1,312	7.56
1966	644	1,873	505	1,172	7.27
1967	594	1,695	517	1,250	8.46
1968	508	1,634	589	1,364	7.34

Table 11.—Apparent consumption of coke in the United States

(Thousand short tons)

Year	Total production	Imports	Exports	Net change in stocks	Apparent consumption [1]	Consumption: In iron furances [2]		Consumption: All other purposes	
						Quantity	Percent	Quantity	Percent
1964	62,145	103	524	−913	62,637	57,063	91.1	5,574	8.9
1965	66,854	90	834	+731	65,379	59,072	90.4	6,307	9.6
1966	67,402	96	1,102	+376	66,019	59,637	90.3	6,383	9.7
1967	64,580	92	710	+2,390	61,572	56,205	91.3	5,367	8.7
1968	63,653	94	792	+517	62,438	56,238	90.1	6,200	9.9

[1] Production plus imports minus exports, plus or minus net change in stocks.
[2] American Iron and Steel Institute; figures include coke consumed in manufacturing ferroalloys.

Table 12.—Coke and coking coal consumed per short ton of pig iron and ferroalloys produced in the United States

Year	Coke per short tons of pig iron and ferroalloys [1] (pounds)	Yield of coke from coal (percent)	Coking coal per short tons of pig iron and ferroalloys (pounds calculated)
1964	1,323.6	69.6	1,901.7
1965	1,329.5	70.1	1,896.6
1966	1,300.6	69.9	1,860.7
1967	1,287.8	69.6	1,850.2
1968	1,263.4	69.8	1,810.0

[1] American Iron and Steel Institute; consumption of pig iron only, excluding furnaces making ferroalloys, was 1,310 pounds in 1964, 1,312 in 1965, 1,282 in 1966, 1,262 in 1967, and 1,248 in 1968.

Table 13.—Oven coke produced in the United States, used by producers, and sold in 1968, by States[1]

(Thousand short tons and thousand dollars)

State	Produced	Used by producing companies				Commercial sales	
		In blast furnaces		For other purposes[2]		To blast-furnace plants	
	Quantity	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	5,462	3,425	$55,882	472	$5,428	501	$7,673
California, Colorado, Utah	3,174	2,941	79,098	14	332	-------	-------
Connecticut, Maryland, New Jersey, New York	7,599	6,421	118,329	49	448	985	17,446
Illinois	2,074	2,019	43,286	76	2,935	-------	-------
Indiana	8,144	7,467	121,225	13	189	(3)	(3)
Kentucky, Missouri, Tennessee, Texas	2,000	(3)	(3)	(3)	(3)	(3)	(3)
Michigan	3,684	(3)	(3)	(3)	(3)	-------	-------
Minnesota and Wisconsin	844	(3)	(3)	(3)	(3)	(3)	(3)
Ohio	8,428	7,224	119,900	137	2,797	440	7,531
Pennsylvania	18,110	16,747	282,420	22	398	283	4,708
West Virginia	3,360	2,999	57,572	(3)	(3)	-------	-------
Undistributed	-------	4,068	66,815	193	6,531	1,136	17,478
Total 1968	62,878	53,312	944,527	974	19,060	3,345	54,837
At merchant plants	5,879	-------	-------	243	6,047	2,288	37,505
At furnace plants	56,999	53,312	944,527	734	13,013	1,057	17,332
Total 1967	63,775	53,304	892,205	712	18,497	3,244	52,856

State	Commercial sales—Continued							
	To foundries		To other industrial plants		For residential heating		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	557	$17,864	369	$5,698	9	$123	1,436	$31,359
California, Colorado, Utah	(3)	(3)	(3)	(3)	-----	------	250	4,610
Connecticut, Maryland, New Jersey, New York	415	13,920	100	1,969	39	739	1,538	34,074
Illinois	-----	------	(3)	(3)	(3)	(3)	5	74
Indiana	(3)	(3)	(3)	(3)	(3)	(3)	597	14,851
Kentucky, Missouri, Tennessee, Texas	(3)	(3)	96	1,712	(3)	(3)	1,365	25,371
Michigan	(3)	(3)	(3)	(3)	(3)	(3)	399	12,046
Minnesota and Wisconsin	(3)	(3)	(3)	(3)	(3)	(3)	528	15,973
Ohio	(3)	(3)	184	3,044	(3)	(3)	990	22,620
Pennsylvania	(3)	(3)	263	5,882	(3)	(3)	838	19,604
West Virginia	-----	------	(3)	(3)	-----	------	330	1,494
Undistributed	1,962	63,343	871	11,766	65	1,179	------	-------
Total 1968	2,934	95,127	1,883	30,071	113	2,041	8,275	182,076
At merchant plants	2,673	86,127	719	14,456	112	2,003	5,793	140,090
At furnace plants	261	9,000	1,164	15,615	1	38	2,482	41,986
Total 1967	2,845	92,176	1,189	20,415	85	1,477	7,364	166,924

---

[1] Data may not add to totals shown because of independent rounding.

[2] Comprises 383,000 tons valued at $13,564,000 used in foundries; 591,000 tons valued at $5,496,000 fo other purposes.

[3] Included with "Undistributed" to avoid disclosing individual company data.

Table 14.—Production and sales of beehive coke in the United States, in 1968, by States[1]

(Thousand short tons and thousand dollars)

State	Produced	Commercial sales									
		To blast-furnace plants		To foundries		To other industrial plants		For residential heating		Total	
	Quantity	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Pennsylvania	355	287	$4,233	30	$199	40	$460	--------	--------	356	$4,892
Virginia	419	283	4,403	1	13	134	2,121	(2)	(2)	419	6,538
Total:											
1968	775	570	8,636	31	212	174	2,581	(2)	(2)	775	11,430
1967	806	806	8,458	17	215	222	3,427	(2)	(2)	805	12,100

[1] Data may not add to totals shown because of independent rounding.

[2] Combined with coke sold "To blast-furnace plants" to avoid disclosing individual company data.

Table 15.—Distribution of oven and beehive coke and breeze in 1968[1] [2]

(Thousand short tons)

Consuming State	Coke					
	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total	Breeze
Alabama	3,455	299	66	6	3,826	282
Arizona	--------	1	1	--------	2	--------
Arkansas	--------	3	1	--------	4	(3)
California	1,282	60	43	(3)	1,385	72
Colorado	660	10	20	--------	690	79
Connecticut	--------	21	39	3	63	86
Delaware	--------	--------	(3)	--------	(3)	--------
Florida	--------	2	2	(3)	5	23
Georgia	--------	12	3	(3)	16	8
Idaho	--------	(3)	190	--------	190	(3)
Illinois	2,210	232	385	4	2,831	277
Indiana	7,480	157	64	5	7,706	520
Iowa	--------	87	1	(3)	88	--------
Kansas	(3)	17	45	(3)	62	(3)
Kentucky	921	12	57	3	993	67
Louisiana	9	2	46	--------	57	78
Maine	--------	2	7	1	10	--------
Maryland	3,505	18	5	--------	3,528	117
Massachusetts	--------	28	(3)	5	33	--------
Michigan	3,776	809	148	1	4,734	628
Minnesota	354	21	22	(3)	397	34
Mississippi	--------	1	(3)	--------	1	--------
Missouri	9	33	37	(3)	79	7
Montana	--------	1	41	--------	42	3
Nebraska	--------	6	6	--------	12	(3)
Nevada	--------	(3)	--------	--------	(3)	--------
New Hampshire	--------	1	--------	(3)	1	--------
New Jersey	3	69	63	28	163	--------
New Mexico	--------	--------	(3)	--------	(3)	--------
New York	3,835	156	37	(3)	4,028	206
North Carolina	--------	15	25	1	41	8
North Dakota	--------	(3)	3	--------	3	--------
Ohio	8,075	451	432	1	8,959	56
Oklahoma	--------	5	--------	--------	5	--------
Oregon	--------	3	28	--------	31	1
Pennsylvania	16,173	183	247	(3)	16,604	823
Rhode Island	--------	10	--------	1	11	--------
South Carolina	--------	8	9	(3)	17	14
South Dakota	--------	(3)	--------	--------	(3)	--------
Tennessee	(3)	70	69	1	140	124
Texas	846	90	25	1	962	78
Utah	998	16	29	--------	1,043	--------
Vermont	--------	1	--------	--------	1	71
Virginia	2	83	2	--------	87	(3)
Washington	--------	22	(3)	--------	22	1
West Virginia	2,813	8	32	--------	2,853	270
Wisconsin	--------	140	3	(3)	143	39
Wyoming	--------	--------	3	--------	3	(3)
Total	56,406	3,166	2,236	63	61,872	3,973
Exported	251	118	229	48	646	74
Grand total	56,657	3,284	2,465	111	62,518	4,047

---

[1] Based upon reports from producers showing destination and principal end use of coke used and sold. Does not include imported coke which totaled 94,085 tons in 1968.

[2] Data may not add to totals shown because of independent rounding.

[3] Less than ½ unit.

Table 16.—Producers' stocks of coke and breeze in the United States on Dec. 31, 1968, by States[1]

(Thousand short tons)

State	Coke				Breeze
	Blast furnace	Foundry	Residential heating and other	Total	
OVEN COKE					
Alabama	1,245	4	5	1,254	19
California, Colorado, Utah	229	-------	-------	229	27
Connecticut, Maryland, New Jersey, New York	544	26	23	593	449
Illinois	44	-------	(2)	44	25
Indiana	449	9	16	474	42
Kentucky, Missouri, Tennessee, Texas	27	12	30	69	8
Michigan	167	57	(2)	224	93
Minnesota and Wisconsin	89	30	23	142	59
Ohio	460	10	49	520	121
Pennsylvania	2,296	42	31	2,368	167
West Virginia	68	-------	-------	68	1
Total 1968	5,617	190	178	5,985	1,012
At merchant plants	22	169	156	348	192
At furnace plants	5,595	21	22	5,637	820
Total 1967	4,980	197	290	5,467	1,000
BEEHIVE COKE					
Pennsylvania	(2)	-------	-------	(2)	-------
Virginia	(2)	-------	1	1	-------
Total:					
1968	1	-------	1	1	-------
1967	1	1	(2)	1	(2)

[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.

Table 17.—Producers' month-end stocks of oven coke in the United States

(Thousand short tons)

Month	At merchant plants		At furnace plants		Total	
	1967	1968	1967	1968	1967	1968
January	231	495	3,018	4,879	3,249	5,375
February	232	460	3,156	4,766	3,388	5,226
March	254	437	3,273	4,579	3,527	5,016
April	267	501	3,465	4,240	3,732	4,740
May	277	373	3,687	4,152	3,963	4,525
June	299	344	4,051	3,992	4,350	4,336
July	396	359	4,371	3,953	4,766	4,312
August	421	410	4,595	4,329	5,016	4,739
September	453	424	4,824	4,969	5,277	5,393
October	467	395	4,972	5,364	5,439	5,759
November	477	338	5,022	5,590	5,499	5,929
December	506	348	4,961	5,637	5,467	5,985

Table 18.—Average receipts per short ton of coke sold (commercial sales) in the United States, by uses

Year	To blast-furnace plants	To foundries	To other industrial plants	For residential heating	Total
	OVEN COKE				
1964	$15.54	$30.43	$15.79	$16.28	$20.73
1965	16.46	30.94	16.41	17.12	21.68
1966	16.33	31.75	16.90	17.39	22.22
1967	16.29	32.40	17.16	17.35	22.67
1968	16.40	32.43	15.97	17.96	22.00
	BEEHIVE COKE				
1964	$14.34	$17.54	$15.68	$15.68	$15.00
1965	14.45	15.40	16.12	16.12	14.96
1966	13.58	15.30	16.77	16.77	14.60
1967	14.97	12.34	15.41	15.41	15.03
1968	15.14	6.84	14.80	18.60	15.00

Table 19.—Coke exported from the United States, by country and by customs district

	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Australia	193	$3	152	$3	175	$4
Bolivia	134	2	34	2	22	1
Brazil	12,913	417	7,144	248	8,205	267
Canada	854,687	18,165	439,853	10,562	247,515	6,840
Chile	220	10	147	7	(1)	(1)
Colombia	---------	---------	266	4	466	17
Dominican Republic	21	1	41	2	349	9
Germany, West	---------	---------	12	1	468	10
India	1,420	33	---------	---------	1,697	47
Japan	275	15	21,312	392	39,010	451
Mexico	124,146	3,154	162,022	4,142	346,547	8,776
Netherlands	r 317	r 48	627	9	---------	---------
Nigeria	607	10	---------	---------	---------	---------
Philippines	---------	---------	148	2	1,038	31
Tunisia	18,510	423	---------	---------	---------	---------
United Kingdom	673	13	40	1	188	4
Venezuela	51,448	798	77,807	1,103	145,919	2,128
Other	973	64	775	14	310	28
Total	r 1,066,487	r 23,156	710,380	16,492	791,909	18,613
CUSTOMS DISTRICT						
Baltimore	766	18	r 554	13	1,185	35
Buffalo	499,695	10,784	238,578	5,751	125,296	3,316
Chicago	76,210	1,088	---------	---------	---------	---------
Detroit	186,505	4,087	144,771	3,282	85,231	2,372
Duluth	3,043	63	3,190	108	4,000	132
El Paso	37	1	223	4	9,060	233
Great Falls	710	20	360	12	---------	---------
Houston	7,070	224	3,746	136	2,565	71
Laredo	123,378	3,127	161,102	4,120	336,964	8,523
Los Angeles	---------	---------	21,151	390	39,164	450
Mobile	909	54	47,048	672	145,036	2,102
New Orleans	603	42	784	16	150	29
New York City	4,765	167	2,931	81	5,233	174
Ogdensburg	50,420	975	16,413	316	5,358	124
Pembina	23,290	689	26,191	737	15,730	492
Philadelphia	70,952	1,255	30,483	427	4,550	137
Port Arthur	2,204	71	1,653	53	---------	---------
St. Albans	700	24	2,220	93	---------	---------
San Diego	629	20	458	10	248	8
Seattle	14,016	430	8,130	262	11,520	390
Other	r 585	r 17	394	9	619	25
Total	r 1,066,487	r 23,156	710,380	16,492	791,909	18,613

r Revised.

[1] 39 short tons ($11,063), reported by the Bureau of the Census, has been deleted.

Table 20.—Coke imported for consumption in the United States, by country and customs district

	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
COUNTRY						
Canada	92,281	$1,464	87,549	$1,295	90,580	$1,630
France	--------	--------	80	9	52	6
Germany, West	3,099	286	3,650	326	2,668	186
Mexico	--------	--------	84	2	--------	--------
Netherlands	70	9	638	72	785	82
Switzerland	311	31	--------	--------	--------	--------
Total	95,761	1,790	92,001	1,704	94,085	1,904
CUSTOMS DISTRICT						
Buffalo	9,967	51	8,115	38	2,362	23
Detroit	57	1	30	1	4,083	44
Galveston	--------	--------	152	15	--------	--------
Great Falls	64,762	1,112	64,795	1,138	78,285	1,462
Honolulu	495	16	330	10	218	7
Houston	--------	--------	16	3	--------	--------
New Orleans	2,985	309	3,388	361	3,078	249
Nogales	--------	--------	--------	--------	492	9
Ogdensburg	139	5	10,000	40	--------	--------
Pembina	79	2	--------	--------	--------	--------
Portland, Maine	76	2	35	1	17	(1)
St. Albans	32	(1)	44	1	35	1
San Juan	--------	--------	482	18	529	21
Seattle	17,169	291	4,614	78	4,986	88
Total	95,761	1,790	92,001	1,704	94,085	1,904

[1] Less than ½ unit.

Table 21.—World production of coke, by country and type (excluding breeze)[1]

(Thousand short tons)

Kind of coke and country [2]	1964	1965	1966	1967	1968 [p]
METALLURGICAL COKE [3]					
North America:					
Canada [4]	4,343	4,369	4,426	4,430	5,311
Mexico	866	908	[r] 953	[r] 1,135	1,271
United States	62,145	66,854	67,402	64,580	63,653
South America:					
Argentina	497	508	[r] 437	514	NA
Brazil	1,005	1,002	1,367	1,444	1,551
Chile	271	235	[r] 255	[r] 316	NA
Colombia	463	480	356	[4] 122	246
Peru	29	30	39	45	NA
Europe:					
Austria	1,773	1,706	1,625	1,551	1,887
Belgium	7,969	8,084	7,673	7,559	[e] 7,716
Bulgaria	519	808	[r] 882	[e] 882	[e] 882
Czechoslovakia	[r] 10,048	[r] 10,239	[r] 10,205	10,114	NA
Finland	33	35	42	44	[e] 55
France [5]	15,439	14,781	14,244	13,923	13,541
Germany, East	3,746	3,537	3,517	[r] 3,220	NA
Germany, West [6]	47,785	47,723	43,971	[r] 38,770	39,867
Hungary	733	708	712	[r] 715	551
Italy	5,162	6,324	6,908	6,885	7,139
Netherlands [5]	4,976	4,723	4,219	3,653	3,231
Norway	119	222	254	333	[e] 331
Poland	14,358	14,544	14,855	15,351	NA
Rumania	1,302	1,251	1,216	[r] 1,247	[e] 1,243
Spain [6]	2,832	[r] 3,037	[r] 3,085	3,180	3,784
Sweden	413	413	551	560	[e] 551
U.S.S.R.[5]	73,063	74,364	[r] 75,501	[r] 77,048	[e] 78,264
United Kingdom	18,982	19,159	18,051	17,157	18,228
Yugoslavia	1,200	1,271	[r] 1,284	[r] 1,275	[e] 1,278
Africa:					
Rhodesia, Southern	143	[r] 192	[r] [1] 224	[8] 226	NA
South Africa, Republic of:	2,636	3,521	3,174	[e] 3,307	[e] 3,307
United Arab Republic	39	266	[r] 302	303	NA
Asia:					
China, mainland [e]	[r] 16,535	17,600	18,700	14,330	16,535
India	[r] 8,067	[r] 8,792	[r] 8,995	8,367	[e] 8,818
Iran [7]	22	[r] 24	[r] 23	23	23
Japan	15,098	[r] 17,391	[r] 19,641	24,439	27,635
Korea, North [e]	1,500	[r] 1,709	1,700	1,984	2,205
Taiwan	224	232	[r] [e] 226	[e] 228	[e] 227
Turkey [4] [7]	[r] 1,543	[r] 1,577	[r] 1,606	1,510	1,576
Oceania: [8]					
Australia	[r] 3,192	3,413	3,566	[r] 3,755	4,360
New Zealand	7	7	7	6	[e] 6
Subtotal—Metallurgical coke	329,077	342,039	342,194	334,531	315,272
GASHOUSE COKE [9]					
South America:					
Brazil	309	241	247	226	218
Chile	91	89	[e] 88	[e] 88	NA
Uruguay	23	22	23	23	22
Europe:					
Austria	345	315	246	235	NA
Czechoslovakia	337	354	228	[r] 145	NA
Denmark	467	363	349	271	244
Finland	127	121	127	106	[e] 83
France	67	22	15	10	9
Germany, West	5,415	4,578	3,942	3,163	2,565
Greece	18	19	[r] 20	[r] 20	NA
Hungary	[r] 600	[r] 667	659	605	NA
Ireland [5]	144	141	116	[r] 102	[e] 90
Italy	597	425	375	349	296
Luxembourg	31	14	[e] 11	---------	---------
Netherlands [5]	120	108	66	20	---------
Norway	25	25	11	---------	---------
Poland	1,318	1,393	1,421	[r] 1,406	NA
Portugal	11	[r] 11	[r] 14	11	[e] 11
Spain [5]	198	[r] 110	[r] 86	61	7
Sweden	606	584	601	550	[e] 551
Switzerland	517	498	[r] 451	303	276
United Kingdom	[r] 9,857	8,701	8,066	6,930	5,125
Yugoslavia	19	15	12	8	[e] 8

See footnotes at end of table.

Table 21.—World production of coke, by country and type (excluding breeze)—Continued[1]

(Thousand short tons)

Kind of coke and country[2]	1964	1965	1966	1967	1968[p]
GASHOUSE COKE—Continued					
Africa:					
Algeria	44	39	[e] 28	[e] 28	[e] 33
South Africa, Republic of:	[r] 149	[r] 179	194	[e] 193	193
United Arab Republic	[e] 39	[e] 44	[e] 55	---------	---------
Asia:					
Hong Kong[5]	14	14	11	10	---------
India	76	71	[r] 72	[r] 79	[e] 79
Japan	4,102	4,045	4,093	4,591	4,927
Taiwan	[r] 46	[r] 51	[r] 57	[e] 50	[e] 55
Oceania:					
Australia[5]	858	825	[e] 696	[e] 827	[e] 727
New Zealand[10]	88	76	74	62	[e] 66
Subtotal—Gashouse coke	26,658	24,160	22,454	20,472	15,585
ALL OTHER TYPES[11]					
North America: United States	203	149	168	163	174
Europe:					
Czechoslovakia	2,126	1,866	1,954	[r] 1,997	NA
France	326	266	274	[r] 219	241
Germany, East[12]	8,386	8,093	8,072	[r] 7,670	NA
Germany, West	657	637	598	434	---------
Poland	276	287	[e] 276	[e] 276	NA
Asia:					
India	[r] 2,432	[r] 2,878	[r] 3,175	[e] 3,307	[e] 3,307
Japan[6]	77	77	72	72	72
Subtotal—All other types	14,483	14,253	14,589	14,138	3,794
Grand total—All types[13]	370,218	380,452	379,237	369,141	334,651

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Beehive coke, where produced, is included with oven coke.

[2] Production data for gashouse coke for Ceylon, Malysia, mainland China, Mexico, Rumania, U.S.S.R., and possibly other countries are not available.

[3] Includes coke produced at high temperature in conventional carbonizing equipment (slot and beehive coke ovens).

[4] Includes breeze and small amount of gas coke.

[5] Includes breeze.

[6] Includes a small amount of low-temperature coke.

[7] Year ended March 20 following that stated.

[8] Production of coke made from imported coal for use in nickel smelter.

[9] Includes coke produced at high temperatures in carbonizing equipment designed primarily for gas manufacture. (Horizontal and vertical coal-gas retorts)

[10] Year ended March 31 of the year following that stated.

[11] Includes coke produced at low and medium temperatures; also, coke produced in unconventional equipment (chain-grate cokers).

[12] Includes high-temperature coke.

[13] Total is of listed figures only; oven coke includes small quantities of other coke.

Table 22.—Quantity and value at ovens of coal carbonized in the United States in 1968, by States[1]

State	Coal carbonized			Coal per ton of coke	
	Thousand short tons	Value		Short tons	Value
		Total (thousands)	Average		
OVEN COKE					
Alabama	7,710	$77,423	$10.04	1.41	$14.17
California, Colorado, Utah	5,022	62,614	12.47	1.58	19.73
Connecticut, Maryland, New Jersey, New York	10,896	131,242	12.04	1.43	17.26
Illinois	3,086	29,992	9.73	1.49	14.46
Indiana	11,641	124,369	10.68	1.43	15.26
Kentucky, Missouri, Tennessee, and Texas	2,898	23,562	8.13	1.45	11.78
Michigan	4,986	53,085	10.65	1.35	14.41
Minnesota and Wisconsin	1,090	12,151	11.15	1.29	14.40
Ohio	12,000	112,350	9.37	1.42	13.34
Pennsylvania	25,764	234,994	9.12	1.42	12.97
West Virginia	4,939	39,512	8.00	1.47	11.76
Total 1968	90,029	901,295	10.01	1.43	14.33
At merchant plants	8,259	79,640	9.64	1.40	13.54
At furnace plants	81,770	821,655	10.05	1.43	14.42
Total 1967	91,428	916,520	10.02	1.43	14.37
BEEHIVE COKE					
Pennsylvania	585	3,462	5.92	1.65	9.74
Virginia	683	3,776	5.53	1.63	9.00
Total:					
1968	1,268	7,238	5.71	1.64	9.34
1967	1,372	8,201	5.98	1.70	10.18

[1] Data may not add to totals shown because of independent rounding.

Table 23.—Bituminous coal carbonized in coke ovens in the United States, by months[1]

(Thousand short tons)

Month	1967			1968		
	Slot	Beehive	Total	Slot	Beehive	Total
January	7,760	199	7,959	7,975	120	8,095
February	7,109	152	7,261	7,634	113	7,747
March	7,890	103	7,993	8,082	131	8,213
April	7,520	99	7,619	7,870	134	8,004
May	7,754	96	7,850	8,122	135	8,257
June	7,251	90	7,341	7,840	117	7,957
July	7,303	78	7,381	7,835	103	7,938
August	7,444	98	7,543	7,198	97	7,295
September	7,358	93	7,452	6,561	85	6,646
October	7,723	120	7,843	6,524	76	6,600
November	7,731	122	7,853	6,632	78	6,710
December	8,056	122	8,179	7,224	79	7,303
Total	90,900	1,372	92,272	89,497	1,268	90,765

[1] Data may not add to totals shown because of independent rounding.

Table 24.—Anthracite carbonized at oven-coke plants in the United States, by months

(Thousand short tons)

Month	1967	1968
January	48	45
February	43	45
March	46	45
April	46	43
May	45	46
June	42	42
July	37	40
August	48	44
September	42	41
October	40	45
November	46	45
December	44	51
Total [1]	528	532

[1] Data may not add to totals shown because of independent rounding.

Table 25.—Average value per short ton of coal carbonized at oven-coke plants in the United States, by States

State	1967	1968
Alabama	$9.95	$10.04
California, Colorado, Utah	12.39	12.47
Connecticut, Maryland, New Jersey, New York	11.79	12.05
Illinois	9.37	9.73
Indiana	10.73	10.68
Kentucky, Missouri, Tennessee, Texas	9.59	8.13
Michigan	10.31	10.65
Minnesota and Wisconsin	11.56	11.15
Ohio	9.25	9.37
Pennsylvania	9.20	9.12
West Virginia	7.80	8.00
Average	10.02	10.01
Value of coal per ton of coke	14.37	14.33

Table 26.—Average volatile content of bituminous coal carbonized by oven-coke plants in the United States[1]

Year	High		Medium		Low		Total	
	Thousand short tons	Volatile content (percent)	Thousand short tons	Volatile content (percent)	Thousand short tons	Volatile content (percent)	Thousand short tons	Volatile content (percent)
1964	58,012	35.2	11,152	25.9	17,569	17.5	86,732	30.4
1965	61,725	35.2	11,791	25.9	18,570	17.8	92,086	30.5
1966	63,061	34.6	10,395	26.2	20,067	17.8	93,523	30.1
1967	59,787	35.1	12,470	26.4	18,644	18.2	90,900	30.4
1968	55,853	35.0	12,906	27.3	20,074	18.7	88,833	30.2

[1] Data may not add to totals shown because of independent rounding.

Table 27.—Coal received by oven-coke plants in the United States in 1968, by consuming States and volatile content[1][2]

(Thousand short tons)

Consuming State	High-volatile		Medium-volatile		Low-volatile		Total coal receipts
	Quantity	Percent of total	Quantity	Percent of total	Quantity	Percent of total	
Alabama	1,309	17.2	5,633	73.8	690	9.0	7,632
California, Colorado, Utah	4,189	83.5	756	15.1	70	1.4	5,015
Connecticut, Maryland, New Jersey, New York	6,934	67.0	626	6.0	2,794	27.0	10,354
Illinois	2,148	69.6	269	8.7	671	21.7	3,087
Indiana	6,824	59.6	2,077	18.1	2,552	22.3	11,453
Kentucky, Missouri, Tennessee, Texas	1,667	59.4	293	10.4	846	30.2	2,806
Michigan	3,086	62.9	376	7.7	1,446	29.4	4,908
Minnesota and Wisconsin	495	47.5	80	7.7	467	44.8	1,042
Ohio	8,881	77.1	206	1.7	2,437	21.2	11,524
Pennsylvania	17,836	68.2	886	3.4	7,422	28.4	26,144
West Virginia	4,114	82.5	71	1.4	799	16.1	4,984
Total 1968	57,483	64.6	11,272	12.7	20,194	22.7	88,949
At merchant plants	3,421	39.0	1,135	12.9	3,360	48.1	7,916
At furnace plants	54,062	67.5	10,137	12.6	16,834	19.9	81,033
Total 1967	60,484	64.3	12,559	13.4	20,997	22.3	94,040

[1] Volatile matter on moisture-free basis: High-volatile—over 31 percent; medium-volatile—22 to 31 percent; and low-volatile—14 to 22 percent.

[2] Data may not add to totals shown because of independent rounding.

Table 28.—Origin of coal received by oven-coke plants in the United States in 1968, by producing county and volatile content[1]

(Thousand short tons)

State and county where coal was produced	Volatile content[2]			Total
	High	Medium	Low	
Alabama:				
Bibb	125	--------	--------	125
Jefferson	303	5,121	--------	5,424
Walker	30	--------	--------	30
Colorado:				
Gunnison	660	--------	--------	660
Las Animas	1,062	--------	--------	1,062
Moffat	(3)	--------	--------	(3)
Pitkin	--------	[4] 682	--------	[4] 682
Illinois:				
Franklin	1,410	--------	--------	1,410
Jefferson	852	--------	--------	852
Saline	176	--------	--------	176
Williamson	16	--------	--------	16
Kentucky:				
Boyd	1,380	--------	--------	1,380
Floyd	1,224	--------	--------	1,224
Harlan	2,740	--------	--------	2,740
Knott	31	--------	--------	31
Letcher	1,157	--------	--------	1,157
Pike	4,014	--------	--------	4,014
New Mexico: Colfax	705	--------	--------	705
Oklahoma:				
Haskell	--------	189	--------	189
Le Flore	--------	--------	144	144
Rogers	186	--------	--------	186
Pennsylvania:				
Anthracite	--------	--------	309	309
Bituminous:				
Allegheny	2,424	--------	12	2,436
Cambria	--------	181	2,641	2,822
Fayette	92	--------	--------	92
Greene	5,929	--------	--------	5,929
Indiana	--------	20	--------	20
Somerset	--------	--------	585	585
Washington	11,845	--------	--------	11,845
Westmoreland	1,633	52	--------	1,685
Utah: Carbon	1,761	--------	--------	1,761
Virginia:				
Buchanan	341	324	748	1,413
Dickenson	765	152	7	924
Russell	814	488	6	1,308
Tazewell	--------	138	--------	138
Wise	1,022	--------	--------	1,022
West Virginia:				
Barbour	350	--------	--------	350
Boone	1,920	5	--------	1,925
Fayette	2,529	46	815	3,390
Greenbrier	--------	118	--------	118
Kanawha	580	72	--------	652
Logan	3,949	462	--------	4,411
McDowell	10	1,792	9,692	11,494
Marion	2,535	--------	--------	2,535
Mercer	--------	--------	1,093	1,093
Mingo	1,907	--------	--------	1,907
Nicholas	686	671	--------	1,357
Raleigh	--------	--------	1,647	1,647
Wayne	--------	197	--------	197
Webster	--------	34	--------	34
Wyoming	371	534	2,496	3,401
Total	57,484	11,269	20,195	88,948

---

[1] Data may not add to totals shown because of independent rounding.

[2] Volatile matter on moisture-free basis: High-volatile—over 31 percent; medium-volatile—22 to 31 percent; and low-volatile—14 to 22 percent.

[3] Less than ½ unit.

[4] Includes small quantity imported from Canada.

Table 29.—Origin of coal received by oven-coke plants in the United States in 1968, by States[1]

(Thousand short tons)

Consuming State	Producing State					
	Alabama	Colorado	Illinois	Kentucky	New Mexico	Oklahoma
Alabama	5,569	--------	--------	--------	--------	--------
California, Colorado, Utah	--------	2,404	--------	--------	705	--------
Connecticut, Maryland, New Jersey, New York	--------	--------	--------	1,768	--------	--------
Illinois	--------	--------	1,147	984	--------	--------
Indiana	--------	--------	1,307	3,196	--------	--------
Kentucky, Missouri, Tennessee, Texas	10	--------	--------	--------	--------	469
Michigan	--------	--------	--------	1,693	--------	--------
Minnesota and Wisconsin	--------	--------	--------	115	--------	--------
Ohio	--------	--------	--------	707	--------	--------
Pennsylvania	--------	--------	--------	1,962	--------	--------
West Virginia	--------	--------	--------	119	--------	--------
Total 1968	5,579	2,404	2,454	10,544	705	469
At merchant plants	661	--------	--------	136	--------	--------
At furnace plants	4,918	2,404	2,454	10,408	705	469
Total 1967	5,922	2,345	1,961	10,951	607	449

Consuming State	Producing State—Continued				Total
	Pennsylvania	Utah	Virginia	West Virginia	
Alabama	45	----------	1,333	685	7,632
California, Colorado, Utah	----------	1,761	----------	144	5,014
Connecticut, Maryland, New Jersey, New York	3,968	----------	579	4,039	10,354
Illinois	8	----------	49	898	3,086
Indiana	54	----------	739	6,156	11,452
Kentucky, Missouri, Tennessee, Texas	51	----------	155	2,121	2,806
Michigan	22	----------	256	2,937	4,908
Minnesota and Wisconsin	26	----------	388	514	1,043
Ohio	4,630	----------	565	5,622	11,524
Pennsylvania	13,799	----------	653	9,730	26,144
West Virginia	3,115	----------	83	1,668	4,985
Total 1968	25,718	1,761	4,800	34,514	88,948
At merchant plants	232	----------	739	5,967	7,735
At furnace plants	25,486	1,761	4,061	28,547	81,213
Total 1967	29,143	1,823	6,510	34,330	94,040

[1] Data may not add to totals shown because of independent rounding.

Table 30.—Quantity and percentage of captive coal received by oven-coke plants in the United States[1]

(Thousand short tons)

Year	At merchant plants			At furnace plants			Total		
	Total coal received	Captive coal		Total coal received	Captive coal		Total coal received	Captive coal	
		Quantity	Percent		Quantity	Percent		Quantity	Percent
1964	9,208	3,172	34.5	81,129	53,265	65.7	90,336	56,437	62.5
1965	9,167	3,229	35.2	84,654	55,228	65.2	93,820	58,457	62.3
1966	8,670	3,006	34.7	85,694	54,155	63.2	94,364	57,161	60.6
1967	8,545	3,109	36.4	85,495	52,928	61.9	94,040	56,038	59.6
1968	7,735	2,659	34.4	81,213	48,999	60.3	88,948	51,658	58.1

[1] Data may not add to totals shown because of independent rounding.

Table 31.—Month-end stocks of bituminous coal at oven-coke plants in the United States

(Thousand short tons)

Month	1967	1968
January	9,244	10,422
February	9,364	9,815
March	9,491	10,492
April	9,829	11,882
May	10,596	11,994
June	11,019	11,633
July	8,774	10,321
August	9,465	10,575
September	9,726	11,203
October	10,611	9,533
November	10,914	9,541
December	10,940	9,537

Table 32.—Month-end stocks of anthracite at oven-coke plants in the United States

(Thousand short tons)

Month	1967	1968
January	127	153
February	103	106
March	83	85
April	86	79
May	90	83
June	101	82
July	106	85
August	129	98
September	136	124
October	151	151
November	149	167
December	157	154

Table 33.—Coal-chemical materials, exclusive of breeze, produced at oven-coke plants in the United States in 1968[1,2]

Product	Produced	Sold			On hand Dec. 31
		Quantity	Value		
			Total (thousands)	Average per unit	
Tar, crude thousand gallons	760,812	358,039	$36,284	$0,101	40,104
Tar derivatives:					
Sodium phenolate or carbolate do	3,205	3,006	251	.083	244
Crude chemical oil (tar acid oil) do	29,150	25,020	5,630	.225	994
Pitch-of-tar: [3]					
Soft thousand short tons	659	187	5,013	26.760	26
Hard do	394	159	3,431	21.606	7
Other tar derivatives: [4]	---------	---------	14,828	---------	---------
Ammonia products:					
Sulfate thousand short tons	670	658	13,789	20.943	137
Liquor (NH_3 content) do	17	17	969	56.408	1
Diammonium phosphate do	31	30	2,747	92.485	2
Total do	---------	---------	17,505	---------	---------
Sulfate equivalent of all forms do	786	755	---------	---------	142
NH_3 equivalent of all forms do	208	198	---------	---------	38
Gas:					
Used under boilers, etc. million cubic feet	922,910	91,875	19,937	.218	---------
Used in steel or allied plants do		446,534	104,402	.235	---------
Distributed through city mains do		[5] 14,840	5,613	.378	---------
Sold for industrial use do		22,153	3,534	.160	---------
Total do	922,910	575,402	133,486	.232	---------
Crude light oil thousand gallons	238,887	[6] 95,511	11,349	.119	10,289
Light-oil derivatives:					
Benzene:					
Specification grades (1°, 2°, 90%) do	88,449	93,049	20,738	.223	2,747
Other industrial grades do	4,136	4,384	573	.131	93
Toluene (all grades) do	19,645	19,867	3,704	.186	1,382
Xylene (all grades) do	5,576	5,473	1,088	.199	585
Solvent naphtha (all grades) do	3,714	2,921	460	.157	416
Other light-oil derivatives do	6,728	3,001	351	.117	337
Total do	128,248	128,695	26,914	.209	5,560
Intermediate light oil do	5,560	1,828	216	.118	232
Grand total	---------	---------	254,907	---------	---------

[1] Data may not add to totals shown because of independent rounding.

[2] Includes products of tar distillation conducted by oven-coke operators under the same corporate name.

[3] Soft-water-softening point less than 110°F; medium—110° to 160°F; hard—over 160°F. Figures on hard pitch include small amount of medium pitch.

[4] Creosote oil, cresols, cresylic acid, naphthalene, phenol, pyridine, refined tar, tar paint.

[5] Includes gas used for heating ovens and gas wasted.

[6] 144,842,000 gallons refined by coke-oven operators to make derived products shown.

Table 34.—Coal equivalent of the thermal materials, except coke, produced at oven-coke plants in the United States

Year	Materials produced: Coke breeze (thousand short tons)	Materials produced: Surplus gas (billion cubic feet)	Materials produced: Tar (thousand gallons)	Materials produced: Light oil (thousand gallons)	Estimated equivalent in heating value [1] (billion Btu): Coke breeze	Estimated equivalent in heating value [1] (billion Btu): Surplus gas	Estimated equivalent in heating value [1] (billion Btu): Tar	Estimated equivalent in heating value [1] (billion Btu): Light oil	Estimated equivalent in heating value [1] (billion Btu): Total	Coke equivalent (thousand short tons)
1964	3,902	582	762,918	248,669	78,040	320,100	114,438	32,327	544,905	20,798
1965	4,037	630	802,738	262,701	80,740	346,500	120,411	34,151	581,802	22,206
1966	4,102	630	801,867	262,640	80,240	346,300	120,280	34,143	580,963	22,174
1967	4,025	606	780,334	252,138	80,500	333,300	117,050	32,778	563,628	21,513
1968	4,074	575	760,812	238,887	81,480	316,250	114,114	31,055	542,899	20,721

[1] Breeze 10,000 Btu per pound; gas, 550 Btu per cubic foot; tar, 150,000 Btu per gallon; and light oil, 130,000 Btu per gallon.

Table 35.—Average value of coal-chemical materials used or sold and of coke and breeze per short ton of coal carbonized in the United States

	1964	1965	1966	1967	1968
Ammonia products	$0.275	$0.268	$0.280	$0.254	$0.194
Light oil and its derivatives	.459	.505	.481	.441	.427
Surplus gas used or sold	1.516	1.556	1.522	1.512	1.483
Tar and its derivatives (including naphthalene):					
Tar burned by producers [1]	.381	.362	.328	.318	.311
Sold	.705	.672	.677	.675	.727
Total	3.336	3.363	3.288	3.200	3.142
Coke produced	12.426	11.890	12.167	12.152	[2] 12.246
Breeze produced	.303	.301	.292	.318	.314
Grand total	16.065	15.554	15.747	15.670	15.702

[1] Includes pitch-of-tar.
[2] Average value of coke used or sold in 1968.

Table 36.—Percentage of coal costs recovered from the recovery of coal-chemical materials in the United States

	1964	1965	1966	1967	1968
Product:					
Ammonia products	3.0	2.8	2.9	2.5	1.9
Light oil and its derivatives	4.9	5.3	4.9	4.4	4.3
Surplus gas used or sold	16.3	16.4	15.6	15.1	15.1
Tar and its derivatives used or sold (including naphthalene)	11.7	11.0	10.3	11.4	10.4
Total	35.9	35.5	33.7	33.4	31.7
Value of coal per short ton	$9.28	$9.51	$9.78	$10.02	$10.01

Table 37.—Production and disposal of coke-oven gas in the United States in 1968, by States[1]

(Million cubic feet)

State	Produced		Used in heating ovens	Surplus used or sold			Wasted
					Value		
	Total	Thousand cubic feet per ton of coal coked		Quantity	Thousands	Average per thousand cubic feet	
Alabama	74,605	9.68	34,149	38,934	$5,645	$0.150	1,522
California, Colorado, Utah	55,147	10.98	17,238	37,471	5,939	.158	437
Connecticut, Maryland, New Jersey, New York	117,869	10.82	38,405	77,954	30,260	.388	1,510
Illinois	31,964	10.37	8,722	20,216	3,650	.183	3,026
Indiana	115,253	9.90	35,705	78,406	14,983	.188	1,142
Kentucky, Missouri, Tennessee, Texas,	25,761	8.89	13,507	11,753	1,728	.147	501
Michigan	47,502	9.52	9,961	36,327	8,780	.242	1,214
Minnesota and Wisconsin	10,464	9.60	5,800	4,601	357	.131	63
Ohio	108,997	9.08	41,026	67,113	17,840	.266	859
Pennsylvania	281,100	10.91	111,765	165,840	34,884	.210	3,496
West Virginia	54,248	10.98	15,563	38,663	9,420	.244	22
Total 1968	922,910	10.25	331,841	577,278	133,486	.232	13,792
At merchant plants	67,052	8.57	32,577	31,909	7,481	.234	2,566
At furnace plants	855,861	10.42	299,264	545,369	126,005	.232	11,226
Total 1967	959,359	10.49	341,753	606,044	138,279	.228	11,561

[1] Data may not add to totals shown because of independent rounding.

Table 38.—Surplus coke-oven gas used by producers in the United States and sold in 1968, by States[1]

(Million cubic feet)

State	Used by producers					
	Under boilers, etc.			In steel or allied plants		
	Quantity	Value		Quantity	Value	
		Thousands	Average per thousand cubic feet		Thousands	Average per thousand cubic feet
Alabama	15,466	$2,224	$0.144	19,449	$2,947	$0.152
California, Colorado, Utah	(2)	(2)	(2)	(2)	(2)	(2)
Connecticut, Maryland, New Jersey, New York	2,543	556	.219	65,981	25,425	.385
Illinois	2,971	423	.142	12,089	2,411	.200
Indiana	3,270	701	.214	71,736	12,999	.181
Kentucky, Missouri, Tennessee, Texas	5,639	710	.126	(2)	(2)	(2)
Michigan	(2)	(2)	(2)	(2)	(2)	(2)
Minnesota and Wisconsin	(2)	(2)	(2)	(2)	(2)	(2)
Ohio	10,951	5,028	.459	50,416	11,951	.237
Pennsylvania	23,840	4,839	.205	140,442	29,782	.212
West Virginia	(2)	(2)	(2)	(2)	(2)	(2)
Undistributed	27,195	5,455	.201	88,849	18,887	.218
Total 1968	91,875	19,937	.217	448,412	104,402	.234
At merchant plants	8,354	1,367	.164	1,050	235	.224
At furnace plants	83,521	18,570	.222	447,362	104,167	.234
Total 1967	100,069	19,330	.198	399,662	94,657	.237

State	Sold					
	Distributed through city mains			For industrial use		
	Quantity	Value		Quantity	Value	
		Thousands	Average per thousand cubic feet		Thousands	Average per thousand cubic feet
Alabama	(2)	(2)	(2)	2,454	$367	$0.145
California, Colorado, Utah	-------	-------	-------	-------	-------	-------
Connecticut, Maryland, New Jersey, New York	9,256	$4,245	$0,367	(2)	(2)	(2)
Illinois	-------	-------	-------	(2)	(2)	(2)
Indiana	(2)	(2)	(2)	(2)	(2)	(2)
Kentucky, Missouri, Tennessee, Texas	-------	-------	-------	(2)	(2)	(2)
Michigan	-------	-------	-------	(2)	(2)	(2)
Minnesota and Wisconsin	-------	-------	-------	(2)	(2)	(2)
Ohio	-------	-------	-------	5,745	860	.150
Pennsylvania	(2)	(2)	(2)	(2)	(2)	(2)
West Virginia	-------	-------	-------	(2)	(2)	(2)
Undistributed	5,584	1,368	-------	13,953	2,306	-------
Total 1968	14,840	5,613	.378	22,152	3,534	.160
At merchant plants	9,965	3,824	.384	12,540	2,054	.164
At furnace plants	4,875	1,788	.367	9,613	1,480	.154
Total 1967	20,039	8,559	.427	86,274	15,732	.182

---

[1] Data may not add to totals shown because of independent rounding.

[2] Included with undistributed to avoid disclosing individual company confidential data.

Table 39.—Coke-oven gas and other gases used in heating coke ovens in the United States in 1968, by States[1] [2]

(Million cubic feet)

State	Coke-oven gas	Blast-furnace gas	Natural gas	Total coke-oven gas equivalent
Alabama	34,149	----------	----------	34,149
California, Colorado, Utah	17,238	----------	----------	17,238
Connecticut, Maryland, New Jersey, New York	38,405	10,207	399	49,011
Illinois	8,722	5,419	468	14,609
Indiana	35,705	44,752	690	81,147
Kentucky, Missouri, Tennessee, Texas	13,507	----------	----------	13,507
Michigan	9,961	13,294	190	23,445
Minnesota and Wisconsin	5,800	----------	38	5,838
Ohio	41,026	4,058	----------	45,084
Pennsylvania	111,765	11,193	----------	122,958
West Virginia	15,560	6,245	----------	21,805
Total 1968	331,838	95,168	1,785	428,791
At merchant plants	34,452	----------	732	35,184
At furnace plants	297,386	95,168	1,053	393,607
Total 1967	341,753	61,667	2,265	405,685

[1] Adjusted to an equivalent of 550 Btu per cubic foot.
[2] Data may not add to totals shown because of independent rounding.

Table 40.—Coke-oven ammonia produced in the United States and sold in 1968, by States[1]

(Thousand short tons)

State	Active plants[2]	Yield of ammonia sulfate		Production	
		Tons	Pounds per ton of coal coked	As sulfate[3]	As liquor (NH_3 content)
Alabama	7	75	19.40	72	(4)
California	3	84	33.62	61	(4)
Connecticut, Maryland, New Jersey, and New York	5	102	18.81	96	(4)
Illinois	4	27	17.36	27	--------
Indiana	5	87	14.92	77	(4)
Kentucky, Tennessee, Texas	3	17	11.75	(4)	(4)
Michigan	3	28	11.31	26	(4)
Minnesota and Wisconsin	2	5	8.30	(4)	(4)
Ohio	11	98	16.30	87	(4)
Pennsylvania	11	202	15.65	202	--------
West Virginia	3	44	17.66	44	--------
Undistributed	-------	--------	--------	9	17
Total 1968	57	768	17.06	[5] 701	17
At merchant plants	12	53	17.53	18	8
At furnace plants	45	715	16.15	683	9
Total 1967	58	834	18.68	778	14

State	Sold[6]				On hand Dec. 31	
	As sulfate[3]		As liquor (NH_3 content)		As sulfate[3]	Liquor (NH_3 content)
	Quantity	Value	Quantity	Value		
Alabama	70	$1,622	(4)	(4)	12	(7)
California, Colorado, Utah	37	2,009	(4)	(4)	10	(7)
Connecticut, Maryland, New Jersey, and New York	98	1,942	(4)	(4)	13	(7)
Illinois	29	672	------	------	6	-------
Indiana	83	1,773	(4)	(4)	16	(7)
Kentucky, Tennessee, Texas	(4)	(4)	(4)	(4)	(7)	(7)
Michigan	(4)	(4)	(4)	(4)	8	(7)
Minnesota and Wisconsin	(4)	(4)	(4)	(4)	(7)	-------
Ohio	89	1,694	(4)	(4)	17	1
Pennsylvania	202	4,374	------	------	50	-------
West Virginia	46	776	------	------	4	-------
Undistributed	34	1,674	17	969	------	-------
Total 1968	[8] 688	16,535	17	969	137	1
At merchant plants	21	469	8	459	4	(7)
At furnace plants	667	16,067	9	510	134	1
Total 1967	729	22,579	12	683	156	2

---

[1] Data may not add to totals shown because of independent rounding.
[2] Number of plants that recovered ammonia.
[3] Includes diammonium phosphate.
[4] Included with "Undistributed" to avoid disclosing individual company confidential data.
[5] Comprises 670,000 tons af ammonium sulfate and 31,000 tons of diammonium phosphate produced in California, Colorado, and Michigan.
[6] Includes 63,000 tons of ammonium sulfate valued at $1,586,000 exported.
[7] Less than ½ unit.
[8] Comprises 658,000 tons of ammonium sulfate valued at $13,789,000 and 30,000 tons of diammonium phosphate valued at $2,746,700.

Table 41.—Coke-oven tar produced in the United States, used by producers, and sold in 1968, by States[1]

(Thousand gallons)

State	Produced		Used by producers		
	Total	Gallons per ton of coal coked	For refining or topping	As fuel	Other-wise
Alabama	56,360	7.31	(2)	--------	---------
California, Colorado, Utah	49,703	9.90	(2)	(2)	(2)
Connecticut, Maryland, New Jersey, New York	93,865	8.61	(2)	(2)	(2)
Illinois	21,126	6,85	--------	--------	---------
Indiana	92,419	7.94	(2)	(2)	---------
Kentucky, Missouri, Tennessee, Texas	19,173	6.82	--------	--------	(2)
Michigan	33,595	6.73	--------	(2)	(2)
Minnesota and Wisconsin	6,153	5.65	------	----------	(2)
Ohio	106,117	8.84	(2)	49,561	616
Pennsylvania	234,220	9.09	139,844	31,656	784
West Virginia	48,081	9.74	(2)	--------	---------
Undistributed	-------	--------	161,410	23,688	250
Total 1968	760,812	8.45	301,254	104,905	1,650
At merchant plants	54,120	6.55	649	--------	---------
At furnace plants	706,692	8.64	300,605	104,905	1,605
Total 1967	780,334	8.53	291,624	129,009	2,468

State	Sold for refining into tar products			On hand Dec. 31
	Quantity	Value		
		Thousands	Average per gallon	
Alabama	33,102	$3,652	$0.110	7,049
California, Colorado, Utah	28,206	2,769	.098	2,727
Connecticut, Maryland, New Jersey, New York	17,735	1,858	.105	3,807
Illinois	21,165	2,032	.096	918
Indiana	42,723	3,880	.091	3,458
Kentucky, Missouri, Tennessee, Texas	19,233	2,058	.107	390
Michigan	27,631	2,432	.088	807
Minnesota and Wisconsin	5,844	554	.095	794
Ohio	57,608	5,437	.094	6,605
Pennsylvania	73,076	7,209	.099	12,271
West Virginia	31,716	2,731	.086	1,278
Undistributed	----------	----------	----------	-----------
Total 1968	358,039	34,612	.097	40,104
At merchant plants	58,974	4,358	.074	1,910
At furnace plants	299,065	30,254	.101	38,194
Total 1967	354,674	33,686	.095	48,564

[1] Data may not add to totals shown because of independent rounding.

[2] Included with "Undistributed" to avoid disclosing individual company data.

Table 42.—Coke-oven crude light-oil produced in the United States and derived products produced and sold in 1968, by States

(Thousand gallons)

State	Active plants [1]	Crude light oil				Derived products		
		Produced	Gallons per ton of coal coked	Refined on premises [2]	On hand Dec. 31	Produced	Sold [3]	
							Quantity	Value
Alabama	7	17,366	2.25	16,894	1,059	13,751	13,776	$2,979
California, Colorado, Utah	3	16,802	3.35	11,081	291	13,299	10,883	1,919
Connecticut, Maryland, New Jersey, New York	6	33,097	3.04	20,380	1,641	16,837	17,424	3,238
Illinois and Michigan	8	19,759	2.45	1,968	590	(4)	(4)	(4)
Indiana	5	28,697	2.47	364	2,147	(4)	(4)	(4)
Kentucky, Missouri, Tennessee, Texas, West Virginia	7	21,397	2.73	2,448	1,017	2,544	2,561	417
Ohio	11	29,308	2.44	18,409	786	16,384	16,354	3,032
Pennsylvania	11	72,461	2.81	73,298	2,757	65,484	67,777	15,329
Total 1968	58	238,887	2.65	144,842	10,289	128,248	128,775	26,914
At merchant plants	4	23,769	2.88	8,926	1,266	10,324	8,664	705
At furnance plants	54	215,118	2.63	135,916	9,023	117,924	120,111	26,209
Total 1967	56	252,138	2.84	153,871	8,496	127,517	117,178	26,980

[1] Number of plants that recovered crude light oil.
[2] Includes small quantity of material also reported in sales of crude light oil in table 33.
[3] Excludes 95,511,000 gallons of crude light oil valued at $11,349,008 sold as such.
[4] Included with California, Colorado, Utah to avoid disclosing individual company confidential data.

Table 43.—Yield of light-oil derivatives from refining crude light oil at oven-coke plants in the United States

(Percent)

Year	Benzene (all grades)	Toluene (all grades)	Xylene (all grades)	Solvent naphtha (crude and refined)	Other light-oil products
1964	62.3	13.3	3.7	2.3	4.3
1965	63.0	12.8	3.5	2.8	4.1
1966	63.4	12.7	3.4	1.8	3.5
1967	58.9	12.6	3.6	2.4	5.4
1968	63.9	13.6	3.8	2.6	4.6

[1] Included with "Solvent naphtha (crude and refined)."

Table 44.—Benzene and toluene produced at oven-coke plants in the United States, by grades

(Thousand gallons)

Year	Benzene		Toluene (all grades)
	Specification grades (1°, 2°, 90 percent)	Other industrial grades	
1964	116,292	3,516	25,521
1965	117,991	3,927	24,816
1966	110,223	3,709	22,791
1967	86,683	3,959	19,358
1968	88,449	4,186	19,645

Table 45.—Light-oil derivatives produced at oven-coke plants in the United States and sold in 1968, by States

(Thousand gallons and thousand dollars)

State	Benzene (all grades)				Toluene (all grades)			
	Produced	Yield from crude light oil refined (percent)	Sold		Produced	Yield from crude light oil refined (percent)	Sold	
			Quantity	Value			Quantity	Value
Alabama	9,998	59.2	9,862	$2,237	2,629	15.6	2,730	$526
Colorado, Illinois, and Utah	8,047	61.2	8,283	1,618	1,776	13.6	1,613	133
Indiana, Maryland, and New York	13,948	67.2	14,966	2,882	1,658	8.0	1,649	247
Ohio	11,811	64.2	12,065	2,211	2,846	15.5	2,858	581
Pennsylvania	47,036	64.2	50,537	12,040	10,468	14.3	10,754	2,171
Tennessee, Texas and West Virginia	1,745	71.3	1,721	323	269	11.0	263	47
Total 1968	92,585	63.9	97,434	21,311	19,645	13.6	19,867	3,704
At merchant plants	7,625	85.4	6,291	404	1,464	16.4	1,438	199
At furnace plants	84,960	62.5	91,143	20,907	18,181	13.4	18,429	3,505
Total 1967	90,642	58.9	88,169	20,941	19,358	12.6	18,620	3,694

State	Xylene (all grades)				Solvent naphtha (crude and refined)			
	Produced	Yield from crude light oil refined (percent)	Sold		Produced	Yield from crude light oil refined (percent)	Sold	
			Quantity	Value			Quantity	Value
Alabama	574	3.4	722	$170	147	0.9	155	$20
Colorado, Illinois and Utah	362	218	323	65	(2)	(2)	(2)	(2)
Indiana, Maryland and New York	464	2.2	497	70	883	2.6	98	17
Ohio	738	4.0	741	158	696	3.8	691	82
Pennsylvania	3,344	4.6	3,129	613	1,988	2.6	1,976	341
Tennessee, Texas and West Virginia	93	3.8	61	13	(3)	(3)	(3)	(3)
Total 1968	5,576	3.8	5,473	1,088	3,714	2.6	2,921	460
At merchant plants	300	3.4	343	39	18	0.2	82	5
At furnace plants	5,276	3.9	5,181	1,049	3,694	2.7	2,888	454
Total 1967	5,488	3.6	5,763	[r] 1,239	3,633	2.4	2,558	411

[r] Revised.

[1] Data may not add to totals shown because of independent rounding.

[2] Included with Indiana, Maryland, and New York to avoid disclosing individual company confidential data.

[3] Included with Pennsylvania to avoid disclosing individual company confidential data.

Table 46.—Estimated consumption of commercial benzene (excluding motor grade) in the United States, by use[1]

(Million gallons)

	1964	1965	1966	1967 [r]	1968
Styrene	283	312	360	378	398
Phenol (synthetic)	146	161	178	178	165
Dodecylbenzene	31	34	42	45	38
Cyclohexane	117	160	184	172	197
Aniline	21	24	29	30	28
DDT	12	14	14	11	11
Dichlorobenzene and monochlorobenzene	20	20	20	20	20
Maleic anhydride	20	22	28	29	33
Diphenyls	5	5	5	5	5
Nitrobenzene	2	2	2	2	2
Miscellaneous	20	20	20	27	25
Reported	87	45	97	100	80
Total	764	819	979	997	1,002

[r] Revised.

[1] Coal Chemicals Committee, American Coke and Coal Chemicals Institute, Washington, D.C.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/80

Columbium and Tantalum

By Richard F. Stevens, Jr. [1]

Consumption and imports of columbium and tantalum fell during the year as a result of decreased prices for these materials. Although demand for columbium in the form of ferrocolumbium continued at a high level it was 16 percent below the 1967 record high. The primary use for tantalum continued to be as capacitors in the electronics industry. About 1.9 million pounds of combined pentoxides ($Cb_2O_5 + Ta_2O_5$) containing approximately 1.2 million pounds of columbium was released to the industry from government stocks. Of these releases, about 1.4 million pounds ($Cb_2O_5 + Ta_2O_5$) was released on negotiated and sealed-bid basis, while the remainder was released as payment-in-kind for an upgrading contract.

Legislation and Government Programs.—During the year the General Services Administration (GSA) continued its columbite disposal program and sold 835,502 pounds of combined pentoxides ($Cb_2O_5 + Ta_2O_5$) containing 538,907 pounds of columbium (Cb) on a negotiated basis at prices ranging from 72½ to 88 cents per pound. In addition, GSA sold 768,431 pounds of combined pentoxides containing some 477,834 pounds of Cb in three sealed-bid invitations at prices ranging from $0.79 to $1.024 per pound. Because the latter two sales were undersubscribed, it is anticipated that the material not sold, some 100,000 pounds of contained Cb, will be reoffered in 1969.

The companies who purchased columbium and tantalum concentrate from GSA during 1968 are listed below.

Company	Pounds of combined pentoxides (Cb_2O_5 $+Ta_2O_5$)	Approximate columbium content (pounds of Cb)	Approximate tantalum content (pounds of Ta)
Associated Metals & Minerals Corp	17,607	11,267	1,206
Fansteel Inc. (formerly Fansteel Metallurgical Corp.)	26,432	16,712	3,052
Kennametal, Inc	249,114	151,112	26,982
Metallurg Inc	553,998	360,526	29,769
Philipp Brothers	697,548	427,752	49,085
Socomet Inc	14,868	9,500	1,046
South American Minerals and Merchandising Corp. (SAMINCORP)	48,364	31,475	4,258

During the year Shieldalloy Corp., Newfield, N.J., a Division of Metallurg Inc., was awarded a conversion contract by GSA to upgrade Government-furnished columbium concentrate to ferrocolumbium containing some 186,000 pounds of Cb for the Government stockpile. Shieldalloy was paid for these services with 534,860 pounds, combined pentoxides, of columbium concentrate containing about 333,463 pounds of Cb and 47,579 pounds of Ta. The Cb_2O_5 to Ta_2O_5 ratio of this material ranged from 6.68:1 to 9.29:1 and averaged approximately 8.21:1.

Three reports were prepared for the GSA to help that agency base its plans for long-range columbium and tantalum disposal programs.[2]

---

[1] Physical scientist, Division of Mineral Studies.

[2] Charles River Associates Inc. Economic Analysis of the Columbium Industry. Cambridge, Mass., June 1967, 72 pp.

———. Economic Analysis of the Tantalum Industry. Cambridge, Mass., June 1967, 114 pp.

Herman B. Directors Associates, Inc. Columbium-Tantalum. Washington, D.C., May 2, 1967, 120 pp.

Table 1.—Salient columbium statistics

(Thousand pounds)

	1964	1965	1966	1967	1968
United States:					
Mine production of columbite-tantalite concentrates	--------	--------	W	W	W
Releases from Government stocks (Cb content)[1] [2]	--------	--------	1,659	779	1,191
Consumption of concentrate: Columbium metal contained in all raw materials consumed (Cb content)[1]	2,758	2,749	3,873	4,366	3,667
Production of primary products: Columbium metal (Cb content)	95	W	W	W	W
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	820	1,961	3,664	1,960	2,380
Consumption of primary products:					
Columbium metal (Cb content)	124	33	100	111	92
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	1,479	2,199	2,697	3,192	2,696
Exports:					
Columbium ore and concentrate (gross weight)	343	NA	NA	NA	NA
Columbium metal, compounds and alloys (gross weight)	5	4	7	6	7
Imports for consumption:					
Columbium mineral concentrate (gross weight)	4,601	4,892	9,278	7,431	3,657
Columbium metal and columbium-bearing alloys (Cb content)	4	10	4	([3])	1
Ferrocolumbium (Gross weight)[e]	172	691	1,280	629	1,171
World: Production of columbium-tantalum concentrates (gross weight)	11,751	14,617	23,031	21,052	19,966

[e] Estimate.
W Withheld to avoid disclosing individual company confidential information.
NA Not available.
[1] Includes columbium content in raw materials from which columbium is not recovered.
[2] Includes material released as payment-in-kind for upgrading.
[3] Less than ½ unit.

Table 2.—Salient tantalum statistics

(Thousand pounds)

	1964	1965	1966	1967	1968
United States:					
Mine production of columbium-tantalum concentrates	--------	--------	W	W	W
Releases from Government stocks (Ta content)[1] [2]	--------	--------	634	307	163
Consumption of concentrate: Tantalum metal contained in all raw materials consumed (Ta content)[1]	510	775	1,392	1,730	1,060
Production of primary products:					
Tantalum metal (Ta content)	448	712	1,064	1,021	692
Ferrocolumbium and ferrotantalum-columbium (Cb+Ta content)	820	1,961	3,664	1,960	2,380
Consumption of primary products:					
Tantalum metal (Ta content)	214	435	493	443	428
Ferrocolumbium and ferrotantalum- columbium (Cb+Ta content)	1,479	2,199	2,697	3,192	2,696
Exports:					
Tantalum ore and concentrate (gross weight)	200	284	163	75	65
Tantalum metal, compounds, and alloys (gross weight)	32	21	35	59	106
Tantalum and tantalum alloy powder (Ta content)	32	25	51	51	84
Imports for consumption:					
Tantalum mineral concentrate (gross weight)	981	1,196	2,143	1,675	1,230
Tantalum metal and tantalum-bearing alloys (Ta content)	3	26	48	55	18
World: Production of columbium-tantalum concentrates (gross weight)	11,751	14,617	23,031	21,052	19,966

W Withheld to avoid disclosing individual company confidential data.
NA Not available.
[1] Includes tantalum content in raw materials from which tantalum is not recovered.
[2] Includes material released as payment-in-kind for upgrading.

Table 3.—Columbium and tantalum materials in Government inventories as of December 31, 1968

(Thousand pounds, columbium and tantalum content)

Material	Objective	National (strategic) stockpile	Defense Production Act (DPA) inventory	Supplemental stockpile	Total
COLUMBIUM					
Concentrates:	--------	[1] 5,999	4,344	358	10,701
Carbide powder: Stockpile grade	20	21	--------	--------	21
Ferrocolumbium:					
Stockpile grade	930	368	--------	--------	368
Nonstockpile grade	--------	553	--------	--------	553
Metal: Stockpile grade	45	44	--------	--------	44
On order-upgrading [2]	--------	1	--------	--------	1
Oxide powder: Stockpile grade	--------	73	--------	--------	73
On order-upgrading [2]	--------	13	--------	--------	13
TANTALUM					
Tantalum minerals: Stockpile grade	2,947	[3] 3,153	1,136	6	4,295
Carbide powder: Stockpile grade	27	29	--------	--------	29
Metal: Stockpile grade	360	183	--------	--------	183
On order-upgrading [2]	--------	18	--------	--------	18

[1] Includes 209,243 pounds columbium content reserved for upgrading.
[2] Material on order is to be acquired through upgrading contracts.
[3] Includes 3,723 pounds, tantalum content reserved for upgrading.

DOMESTIC PRODUCTION

Domestic activity was insignificant during the year and although three companies, two in South Dakota and one in New Mexico, reported columbite and/or tantalite stocks at yearend, only one company reported production. No domestic material entered the market in 1968.

Production of columbium metal powder decreased approximately 66 percent in 1968 but data continued to be withheld to avoid disclosing individual company confidential data. Production of columbium metal ingots decreased during the year and was also withheld. Production of tantalum metal powder (including capacitor-grade powder) fell 32 percent to 346 tons in 1968 and production of tantalum metal ingots decreased 57 percent to 125 tons.

Ferrocolumbium, ferrotantalum-columbium-base, and/or columbium-base master alloys were produced by the thermite process by the Kawecki Division of Kawecki Berylco Industries, Inc. (formerly Kawecki Chemical Co.), Reading Alloys Co., Inc. and Shieldalloy Corp. Molybdenum Corporation of America (Molycorp), Union Carbide Corp., and the Metallurgical Products Division of Foote Mineral Co. produced these ferroalloys in electric furnaces.

The plant at Reading, Pa., which was constructed in 1967 by Kawecki to recover tantalum from tin slags was operated to evaluate the metallurgical recovery process and then was placed on "standby." This plant will be operated during periods of higher tantalum ore prices and when combined with tantalite imports will provide Kawecki with a constant source of tantalum raw material at a reasonable price level. Tantalum was recovered from Thailand tin slags by Union Carbide Corp. at the company's Marietta, Ohio, plant during the year.

Early in 1969 Ranchers Exploration and Development Corp. obtained from Michigan Chemical Corp. an option on the Idaho euxenite dredging operations originally worked by Porter Brothers Corp. Ranchers' plan to evaluate the economic feasability of adapting extractive metallurgical techniques developed by the Bureau of Mines to the recovery of columbium, tantalum, uranium, thorium, and other mineral values from these black sands.

To take advantage of area's highly specialized metallurgical manpower pool, two new rare metals facilities were constructed and became operational at Albany, Oreg., during the year. Rem Metals Corp. built a $1.5 million plant employing about 60 people to conduct precision casting of columbium, titanium, and zirconium shapes. TiLine, Inc., constructed a 16,000-square-foot plant to cast metal bodies around preformed corrosion-resistant metals. This process permits the use of tantalum, zirconium, and titanium for the lining of valves, pumps, and fittings at greatly reduced costs. TiLine presently employs about 50 people at its new $600,000 facility.

In a new 88,000-square-foot building at its Stellite Works in Kokomo, Ind. the Materials Systems Division of Union Carbide Corp. began operation of the country's first fully integrated refractory metals processing facility. The Stellite works is now capable of coverting columbium, tantalum, and vanadium pentoxides (concentrate) into both metal powders and finished mill products in a straight-line production system. This new centralized system offers consistently high-quality products through the use of continuous quality control operations.

Early in the year the Metals Division of Norton Co., completed a new plant in Newton, Mass., that provided an 80-percent increase in the company's tantalum production capacity.

The Tantalum Producers Association was formed during the year, in part to obtain more accurate statistics and technical information on tantalum.

Table 4.—Major domestic columbium and tantalum processing and producing companies in 1968

Company	Location	Columbium	Tantalum	Tantalum carbide	Ferrocolumbium	Ferrotantalum-columbium
Fansteel Inc	Muskogee, Okla	X	X	X	------	------
General Electric Co	Euclid, Ohio	X	X	------	------	------
Kawecki Division, Kawecki Berylco Industries, Inc.	Boyertown, Pa	X	X	X	X	------
Kennametal, Inc	Latrobe, Pa	X	X	X	------	------
Linde Division, Union Carbide Corp	Indianapolis, Ind	X	X	X	------	------
Mallinckrodt Chemical Works	St. Louis, Mo	X	X	X	------	------
Mining and Metals Division, Union Carbide Corp.	Niagara Falls, N.Y Marietta, Ohio	X	X	------	X	X
Molybdenum Corporation of America	Washington, Pa	------	------	------	X	X
Metals Division, Norton Co	Newton, Mass	X	X	------	------	------
Reading Alloys, Co., Inc	Robesonia, Pa	------	------	------	X	X
Shieldalloy Corp	Newfield, N.J	------	------	------	X	X
Stellite Works, Materials Systems Division, Union Carbide Corp.	Kokomo, Ind	X	X	X	------	------
Metallurgical Products Division, Foote Mineral Co.	Vancoram, Ohio Graham, W. Va	------	------	------	X	X
Wah Chang Albany (A Teledyne Company).	Albany, Oreg	X	X	X	------	------

CONSUMPTION AND USES

Columbium consumption in the form of high-purity metal totaled 92,384 pounds, a 17-percent decrease from 1967. Tantalum metal (including capacitor grade powder) consumed during the year decreased 5 percent and totaled 423,063 pounds. About 60 to 65 percent of this tantalum consumption was in electronic applications as a capacitor, 25 to 30 percent in the chemical industry, and 5 to 10 percent as carbides.

Use of columbium in ferroalloy additions to steels continued to account for approximately 90 percent of the metal consumed. Total consumption of columbium plus tantalum in ferroalloys fell 16 percent to almost 2.7 million pounds in 1968. Domestic consumption of ferrocolumbium (FeCb) during the year, by major use categories, was as follows: Other alloy steels (41 percent), high-temperature nonferrous alloys (23 percent), carbon steels (19 percent), and stainless steels (15 percent).

Consumption of ferrotantalum-columbium (FeTa-Cb) continued to be small and amounted to only slightly more than 1 percent of the total reported FeCb plus FeTa-Cb consumption (table 7) compared with slightly more than 2 percent in 1967. The major uses of ferrotantalum-columbium in 1968 were in the production of stainless steels (93 percent), other alloy steels (3 percent), and high-temperature nonferrous alloys (3 percent).

Additional data on ferrocolumbium and ferrotantalum-columbium are contained in the "Ferroalloy" chapter.

Utilizing electron beam zone refining techniques Westinghouse Electric Corp. has developed ultrapure single crystals of columbium and tantalum in rods up to ¼-inch diameter.

Ultrafine, multistrand, superconducting wire has been developed and is being marketed by Air Reduction Co. Inc. (Airco). The multistrand wire which consists of individual strands of columbium-titanium alloy imbedded in a matrix of copper, is being marketed by Airco under the name Kryoconducter. Commercial production of this wire is being conducted at Airco's manufacturing facility in Franklin Township, N.J.

The world's largest superconducting magnet capable of generating a magnetic field of 20 kilogauss (KG) (20,000 gauss) was installed at Argonne National Laboratory during the year. This magnet was wound with coils of columbium-48-weight-percent titanium alloy in OFHC (oxygen-free, high-conductivity) copper.

On the basis of information supplied by the Electronic Industries Association the production of tantalum capacitors, as measured by sales, increased 6 percent in 1968 to 185.8 million units although the value fell 9 percent to $88.9 million.

A report on the use of tantalum was released during the year which discussed the supply-demand situation for this metal.[3]

As an addition to the Bureau of Mines statistics reported in this chapter, information obtained from industrial sources and based upon shipment data are reported in table 5.

Table 5.—Reported shipments of columbium and tantalum materials

(Pounds of metal content)

Material	1967	1968	Percent change
Columbium products:			
Compounds, including alloys	906,000	2,121,000	+134
Metal, including worked products	92,117	47,363	−49
Total Cb	998,117	2,168,363	+117
Tantalum products:			
Oxides and salts	50,700	63,000	+24
Alloy additive	5,000	16,300	+226
Carbide	82,700	62,350	−25
Powder and anodes	476,717	458,303	−4
Ingot (unworked consolidated metal)	46,600	14,360	−69
Mill products	222,427	171,117	−23
Scrap	8,532	12,163	+43
Other	600	1,100	+83
Total Ta	893,276	798,693	—11

---

[3] National Research Council. Trends in Usage of Tantalum—A Report by the Materials Advisory Board. MAB-242, National Academy of Sciences/National Academy of Engineering, Washington, D.C., February 1968, 21 pp.

Table 6.—Consumption of end uses of ferrocolumbium and ferrotantalum-columbium in the United States

(Pounds of contained columbium plus tantalum)

Product	1965	1966	1967	1968
Stainless steels	601,247	567,307	437,116	421,318
Other alloy steels	974,999	1,181,467	1,400,805	1,096,983
Carbon steels	265,545	362,114	491,460	507,598
Tool steels [1]	1,268	6,013	6,053	3,639
Welding rods [2]	11,492	10,813	12,654	10,933
Gray and malleable castings	158	857	300	----------
High-temperature nonferrous alloys	313,043	537,370	536,572	627,304
Permanent-magnet alloys	5,222	4,512	[e] 1,700	1,794
Nickel-base alloys	11,468	16,684	12,965	9,063
Miscellaneous [3]	14,302	9,666	13,662	4,882
Unspecified	----------	----------	278,424	12,399
Total	2,198,744	2,696,803	3,191,711	2,695,908

[e] Estimate.

[1] Includes high-speed steel.

[2] Includes hard facing alloys and cutting and wear resistant alloys.

[3] Includes electrical resistance alloys, premixed powders, cemented carbides, capacitors, flame plating high-nickel chromium alloy coatings, metal-to-glass seal materials, and unspecified alloy powders.

STOCKS

The following yearend columbium and tantalum materials (given in pounds) were reported in inventories:

Material	December 31, 1967	December 31, 1968
COLUMBIUM		
Primary metal	[r] 63,504	42,268
Ingot	[r] 46,058	43,051
Scrap	35,723	74,193
Oxide	[r] 597,436	679,604
Other compounds	24,703	16,366
TANTALUM		
Primary metal	111,071	154,752
Capacitor-grade powder	[r] 147,941	146,295
Ingot	[r] 155,978	140,162
Scrap	[r] 167,655	181,701
Oxide	[r] 156,889	293,111
Potassium tantalum fluoride (K_2TaF_7)	[r] 267,630	455,881
Other compounds	[r] 56,428	44,040

[r] Revised.

Stocks of columbium and tantalum raw materials, as reported by consumers and dealers at yearend 1968 totaled as follows (in short tons—1967 figures in parentheses): Columbite, 1,020 (1,298); tantalite, 1,972 (1,819); pyrochlore, 464, (433); tin slag, 31,981 (32,852); and other, 233 (104).

Consumer inventories of ferrocolumbium and ferrotantalum-columbium as of December 31, 1968, were as follows (with 1967 yearend stocks in parentheses): Ferrocolumbium, 561,013 pounds contained columbium plus tantalum (Cb+Ta) (681,778); and ferrotantalum-columbium, 16,800 pounds contained Cb+Ta (21,117). Producer stocks of ferrocolumbium at yearend 1968 were 1,194,300 pounds contained Cb ([r] 950,000); producer stocks of ferrotantalum-columbium were withheld to avoid disclosing individual company confidential data.

PRICES

Spot prices for columbite ore, c.i.f. U.S. ports, as reported by Metals Week decreased from $0.90 per pound of contained pentoxides for material having a Cb_2O_5 to Ta_2O_5 ratio of 10:1 at the beginning of 1968 to $0.80 to $0.89 per pound at yearend. Under long-term contracts columbite reportedly sold at discounts from the spot quotations, but prices were subject to negotiation and no quotations were published. The quoted price for Brazilian pyrochlore concentrate, f.o.b. shipping point, remained constant during the year at $0.955 per pound of Cb_2O_5 for both spot and 1-year contracts. At the beginning of the year Canadian pyrochlore concentrate, f.o.b. mine or mill, was quoted at $0.95 per pound of Cb_2O_5 for long-term contracts and at $1.02 to $1.07 per pound on a spot basis. At yearend the long-term contract price had been discontinued and was subject to private negotiation while the spot price was quoted at $0.92 to $0.98 per pound of Cb_2O_5. The price for tantalite ore and concentrate, 60 percent basis, c.i.f. U.S. ports, continued to fall during the year and reportedly was in the range from about $5.50 to $7.50 per pound of contained pentoxides having a Ta_2O_5 to Cb_2O_5 ratio of 3:1.

The price quotations of various grades of ferrocolumbium per pound of columbium content, ton lots, f.o.b. shipping point, remained unchanged during the year and were as follows: Low alloy grade, $2.45 to $2.60; standard grade, $2.45 to $2.60; and high purity grade, $3.82 to $4.50.

The quoted price of tantalum metal, depending upon grade, remained constant during 1968 and was $32 to $46 per pound for powder; $36 to $60 per pound for sheet and $40 to $52 for rod.

Throughout the year the price of columbium metal remained unchanged. Columbium-powder roundels, 99.5 to 99.8 percent purity, was quoted at $11 to $22 per pound for metallurgical grade material and at $12 to $23 per pound for reactor-grade material. Columbium ingots were quoted at $16 to $27 per pound for metallurgical-grade material and at $17.50 to $28 per pound for reactor-grade material.

Table 7.—Average grade of concentrate received by U.S. consumers and dealers in 1968 by country of origin

(Percent of contained pentoxides)

Country	Columbite			Tantalite	
	Cb_2O_5	Ta_2O_5	Ratio	Ta_2O_5	Cb_2O_5
Argentina	43	16	2.7:1	NA	NA
Australia	--------	--------	--------	49	19
Brazil [1] [4]	54	.026	2,080:1	32	29
Canada [2]	52	.11	470:1	--------	--------
Congo (Kinshasa) [3] [4]	38	35	1.1:1	33	38
Malaysia [4]	54	15	3.6:1	NA	NA
Mozambique [3]	62	7.5	8.3:1	49	22
Nigeria [4]	67	7	9.6:1	56	18
Portugal [3]	37	31	1.2:1	39	27
Rhodesia, Southern	NA	NA	NA	47	18
South Africa, Republic of	--------	--------	--------	36	33
Spain [3]	36	32	1.1:1	30	35
Thailand [4]	--------	--------	--------	40	27
Uganda	58	15	3.9:1	NA	NA

NA Not available.

[1] Material reported from Brazil as columbite represents primarily pyrochlore.

[2] Pyrochlore concentrate.

[3] Columbite data estimated.

[4] Excludes tin slag, See footnote 7 of table 14.

FOREIGN TRADE

Most of the columbium and tantalum exports during the year were shipped primarily to Japan, Canada, and Western Europe. Unwrought tantalum metals and alloys, the largest export item by volume, was destined for the United Kingdom (61 percent), West Germany (19 percent), Japan (14 percent), Canada (4 percent), and Austria (2 percent). Tantalum and tantalum alloy powder, the largest value item, was exported primarily to West Germany (23 percent), Japan (22 percent), Austria and the United Kingdom (18 percent each), Italy (7 percent), and France and the Netherlands (6 percent each). Tantalum ore and concentrate, believed not to be of domestic origin, was shipped to Belgium-Luxembourg (62 percent), West Germany (31 percent), and Japan (7 percent).

Table 8.—U.S. exports of columbium and tantalum, by classes

(Thousand pounds, gross weight, and thousand dollars)

Class	1967		1968	
	Quantity	Value	Quantity	Value
Columbium and columbium alloys unwrought and waste and scrap	2	$57	1	$28
Columbium and columbium alloys, wrought	4	284	6	263
Tantalum ores and concentrates	75	224	65	142
Tantalum and tantalum alloys, wrought	10	704	13	727
Tantalum metals and alloys in crude form and scrap	49	796	93	1,030
Tantalum and tantalum alloy powder	r 51	r 1,599	84	2,668

r Revised.

Imports for consumption of unwrought columbium, all from West Germany, more than doubled during the year and totaled 900 pounds, columbium content, valued at $12,510. Imports of unwrought columbium alloy increased by a factor of almost six and totaled 82 pounds valued at $2,852. These imports were received from Switzerland (61 percent), France (21 percent), and West Germany, (18 percent). Imports of wrought columbium, almost all from the United Kingdom, totaled 108 pounds valued at $12,531 in 1968 compared with no transactions in 1967. Imports for consumption of unwrought tantalum metal, including waste and scrap, decreased 70 percent during the year to 16,583 pounds, tantalum content, valued at $176,892. This material was imported primarily from the United Kingdom (55 percent), Belgium-Luxembourg (26 percent), Switzerland (7 percent), and France (6 percent). Imports of unwrought tantalum alloys, all from West Germany, increased to 142 pounds valued at $3,221 during the year. Imports of wrought tantalum, all from the United Kingdom, increased by a factor of 36 to 1,138 pounds valued at $4,983 in 1968.

Table 9.—Receipts of microlite and tin slags reported by consumers

(Thousand pounds)

Material	1966			1967 [1]			1968 [1]		
	Gross weight	Cb_2O_5 content	Ta_2O_5 content	Gross weight	Cb_2O_5 content	Ta_2O_5 content	Gross weight	Cb_2O_5 content	Ta_2O_5 content
Microlite	9	(2)	6	—	—	—	—	—	—
Tin slags	10,220	889	560	28,918	2,902	1,572	8,709	541	510

[1] Microlite reported as tantalum concentrate. See table 11.

[2] Less than ½ unit.

Table 10.—U.S. imports for consumption of columbium-mineral concentrates by countries

(Thousand pounds and thousand dollars)

Country	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Angola	--------	--------	--------	--------	83	$94
Argentina	--------	--------	11	$17	2	6
Australia	--------	--------	1	4	--------	--------
Belgium-Luxembourg [1]	12	$29	83	111	--------	--------
Brazil	4,995	2,622	3,536	1,963	2,163	1,348
Burundi-Rwanda	--------	--------	15	47	8	12
Canada	1,524	870	891	482	295	157
Congo (Kinshasa)	128	226	66	189	207	542
Finland	2	1	--------	--------	--------	--------
Gabon	--------	--------	--------	--------	7	4
Germany, West	--------	--------	80	224	--------	--------
Ivory Coast	15	9	--------	--------	--------	--------
Kenya	7	4	--------	--------	6	6
Malagasy Republic	--------	--------	7	9	--------	--------
Malaysia	74	78	202	272	133	122
Mozambique	--------	--------	11	19	18	34
Netherlands [1]	--------	--------	--------	--------	13	19
Nigeria	2,421	1,673	2,519	1,848	737	431
Peru	14	7	--------	--------	--------	--------
Portugal	28	64	18	29	16	30
Rhodesia, Southern	--------	--------	8	13	3	11
South Africa, Republic of	11	10	--------	--------	--------	--------
Spain	10	16	--------	--------	9	26
Switzerland [1]	22	51	--------	--------	--------	--------
Uganda	15	18	4	5	7	6
United Kingdom	--------	--------	18	15	--------	--------
Western Africa, n.e.c	--------	--------	11	19	--------	--------
Total	9,278	5,678	7,431	5,266	3,657	2,848

[1] Presumably country of transshipment rather than original source.

Table 11.—U.S. imports for consumption of tantalum-mineral concentrates by countries

(Thousand pounds and thousand dollars)

Country	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	10	$33	3	$17	7	$25
Australia	29	93	58	211	71	247
Belgium-Luxembourg [1]	27	90	60	244	15	42
Brazil	287	984	356	1,668	342	1,472
Burundi-Rwanda	20	25	45	136	62	144
Central African Republic	--------	--------	5	32	--------	--------
Congo (Kinshasa)	993	1,768	313	798	242	845
Cyprus	--------	--------	--------	--------	1	1
French Guiana	1	(2)	--------	--------	--------	--------
Germany, West	109	312	--------	--------	22	108
Kenya	27	29	21	53	5	9
Malagasy Republic	1	(2)	15	23	--------	--------
Malaysia	36	41	33	106	15	10
Mozambique	175	508	241	988	306	869
Netherlands [1]	166	101	42	86	41	65
Nigeria	40	123	135	233	20	77
Portugal	67	258	99	262	24	76
Rhodesia, Southern	16	35	41	183	17	72
South Africa, Republic of	8	10	18	98	14	25
Spain	13	29	11	37	14	30
Thailand	89	282	138	212	--------	--------
Uganda	7	7	24	67	12	47
Uruguay	2	4	--------	--------	--------	--------
Western Africa, n.e.c	--------	--------	17	56	--------	--------
Western Portuguese Africa	20	50	--------	--------	--------	--------
Total	2,143	4,782	1,675	5,510	1,230	4,164

[1] Presumably country of transshipment rather than original source.
[2] Less than ½ unit.

Table 12.—Estimated U.S. imports for consumption of ferrocolumbium by major countries

(Thousand pounds, gross weight)

Country	1965	1966	1967	1968
Austria	236	231	22	110
Brazil	370	904	466	1,025
Canada	52	70	41	13
Germany, West	33	75	90	-----
United Kingdom	---	-----	10	23
Total	691	1,280	629	1,171

Table 13.—U.S. import duties

(Per pound)

Tariff classification number	Article	Rate of duty [1] Effective Jan. 1, 1968	Rate of duty [1] Effective Jan. 1, 1969
601.21	Columbium concentrate	Free	Free
601.42	Tantalum concentrate	Free	Free
607.80	Ferrocolumbium and ferrotantalum-columbium	9 percent ad valorem	8 percent ad valorem
	Columbium:		
628.15	Unwrought, waste, scrap	9 percent ad valorem	8 percent ad valorem
628.20	Wrought	16 percent ad valorem	14 percent ad valorem
628.17	Unwrought Cb alloys	13 percent ad valorem	12 percent ad valorem
	Tantalum:		
629.05	Unwrought, waste, scrap	9 percent ad valorem	8 percent ad valorem
629.10	Wrought	16 percent ad valorem	14 percent ad valorem
629.07	Unwrought Ta alloys	13 percent ad valorem	12 percent ad valorem
423.00	Columbium and tantalum chemicals	9 percent ad valorem	8 percent ad valorem

[1] Not applicable to Communist countries.

WORLD REVIEW

Australia.—Vultan Minerals Ltd. was incorporated during the year to explore for and recover minerals from land purchased from its parent organization, the Vultan Syndicate. The company will construct a new plant adjacent to its present facility at Greenbushes, near Perth, Western Australia to increase its treatment capability to tin-tantalite concentrates from the present rate of 1,700 pounds per week. Approximately 20 percent of the concentrate processed is tantalite and the remainder is tin. One of the outstanding features of the new plant will be a high efficiency crusher to liberate additional tin-tantalite concentrate from the ore which presently is not recovered and is deposited in the tailings.

The Canadian firm, Goldrim Mining Co. entered an agreement with Tantalum Mining Corp. of Canada Ltd., whereby the latter firm would provide financing for development of Goldrim's Wodgina tantalite property in Western Australia. In the drilling program conducted during 1968, 75 percent of the drill holes were reported to show good tantalite mineralization.

A detailed evaluation of recent developments at the tantalite recovery operations of Greenbushes Tin N.L. in Western Australia was published which described the extractive metallurgical operations, equipment, and reagents employed.[4] The final tantalite concentrate from this operation assays 48 to 49 percent Ta_2O_5.

During the year a substantial increase in Australian tantalite production was re-

---

[4] Woodcock, J. T. Ore Dressing Developments in Australia, 1967. Australian Min., Melbourne, Australia, v. 60, No. 7, July 15, 1968, pp. 81–83.

Table 14.—Free world production of columbium and tantalum concentrates (gross weight) by countries[1] [2]

(Pounds)

<table>
<tr><th rowspan="2">Country</th><th colspan="2">1964</th><th colspan="2">1965</th><th colspan="2">1966</th><th colspan="2">1967</th><th colspan="2">1968 p</th></tr>
<tr><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th><th>Columbium</th><th>Tantalum</th></tr>
<tr><td>North America: Canada [3]</td><td>4,150,388</td><td>----------</td><td>4,541,745</td><td>----------</td><td>r 5,147,529</td><td>----------</td><td>4,408,000</td><td>----------</td><td>4,236,000</td><td>----------</td></tr>
<tr><td>South America:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Argentina</td><td>----------</td><td>----------</td><td>----------</td><td>r 590</td><td colspan="2">r 12,610</td><td colspan="2">p 6,600</td><td></td><td>NA</td></tr>
<tr><td>Brazil:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Columbite-tantalite [4]</td><td>24,643</td><td>180,777</td><td>88,317</td><td>364,466</td><td>130,611</td><td>351,796</td><td>227,076</td><td>454,152</td><td>138,891</td><td>599,657</td></tr>
<tr><td>Pyrochlore</td><td>712,081</td><td>----------</td><td>2,636,686</td><td>----------</td><td>10,527,061</td><td>----------</td><td>10,198,572</td><td>----------</td><td>11,020,895</td><td>----------</td></tr>
<tr><td>French Guiana</td><td colspan="2">2,000</td><td colspan="2">1,850</td><td colspan="2">2,000</td><td colspan="2">2,200</td><td colspan="2">----------</td></tr>
<tr><td>Europe:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Norway [3]</td><td>408,000</td><td>----------</td><td>330,689</td><td>----------</td><td>----------</td><td>----------</td><td>----------</td><td>----------</td><td>----------</td><td>----------</td></tr>
<tr><td>Portugal [5]</td><td>21,527</td><td>32,281</td><td>----------</td><td>47,772</td><td>27,497</td><td>67,390</td><td>17,973</td><td>99,306</td><td>15,433</td><td>24,303</td></tr>
<tr><td>Spain [5]</td><td>14,610</td><td>----------</td><td>----------</td><td>13,484</td><td>10,186</td><td>13,047</td><td>----------</td><td>10,905</td><td>8,899</td><td>14,231</td></tr>
<tr><td>Africa:</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Congo, (Kinshasa)[5] [6]</td><td>----------</td><td>101,160</td><td>44,125</td><td>159,627</td><td>127,470</td><td>998,270</td><td>66,289</td><td>368,422</td><td>206,562</td><td>219,555</td></tr>
<tr><td>Malagasy Republic</td><td colspan="2">7,900</td><td colspan="2">8,818</td><td>----------</td><td>[6] 990</td><td colspan="2">148</td><td colspan="2">2,990</td></tr>
<tr><td>Mozambique [7]</td><td colspan="2">441,000</td><td colspan="2">302,637</td><td colspan="2">r 299,000</td><td colspan="2">351,500</td><td colspan="2">335,500</td></tr>
<tr><td>Nigeria</td><td>5,239,344</td><td>22,400</td><td>5,707,486</td><td>29,030</td><td>4,986,211</td><td>26,880</td><td>4,309,752</td><td>42,558</td><td>2,527,818</td><td>2,513</td></tr>
<tr><td>Rhodesia, Southern</td><td>----------</td><td>141,318</td><td>----------</td><td>e 77,162</td><td>----------</td><td>e r 59,525</td><td>----------</td><td>NA</td><td>----------</td><td>NA</td></tr>
<tr><td>Rwanda</td><td colspan="2">64,421</td><td colspan="2">109,239</td><td colspan="2">54,756</td><td colspan="2">69,225</td><td colspan="2">61,600</td></tr>
<tr><td>South Africa, Republic of</td><td>----------</td><td>13,228</td><td>----------</td><td>6,600</td><td>----------</td><td>4,400</td><td>----------</td><td>e 11,000</td><td>----------</td><td>39,683</td></tr>
<tr><td>South-West Africa</td><td>448</td><td>1,027</td><td>1,080</td><td>1,135</td><td colspan="2">1,892</td><td colspan="2">NA</td><td colspan="2">NA</td></tr>
<tr><td>Uganda</td><td colspan="2">12,857</td><td colspan="2">17,924</td><td colspan="2">24,648</td><td colspan="2">59,763</td><td colspan="2">e 59,400</td></tr>
<tr><td>Asia: Malaysia</td><td>r 125,663</td><td>----------</td><td>r 101,413</td><td>----------</td><td>r 152,119</td><td>----------</td><td>195,991</td><td>----------</td><td>114,240</td><td>----------</td></tr>
<tr><td>Thailand [6]</td><td colspan="2">----------</td><td colspan="2">----------</td><td colspan="2">----------</td><td colspan="2">101,412</td><td colspan="2">88,184</td></tr>
<tr><td>Oceania: Australia</td><td>----------</td><td>r 33,600</td><td>----------</td><td>25,581</td><td>----------</td><td>10,550</td><td>----------</td><td>51,229</td><td>----------</td><td>e 250,000</td></tr>
<tr><td>Total [8]</td><td colspan="2">r 11,750,673</td><td colspan="2">r 14,617,456</td><td colspan="2">r 23,031,438</td><td colspan="2">21,052,073</td><td colspan="2">19,966,354</td></tr>
</table>

e Estimare. p Preliminary. r Revised. NA Not available.

[1] When the content of neither Cb_2O_5 nor Ta_2O_5 decisively predominates, or when insufficient identification is available, the production figure has been centered. This data excludes columbium and tantalum-bearing tin slags.

[2] The U.S.S.R. is known to produce columbium and possibly tantalum concentrates, but specific quantitative data are not available.

[3] Represents pyrochlore concentrates.

[4] Exports.

[5] U.S. imports.

[6] In addition, tin-tantalum-columbium concentrate from tin-slag (averaging about 10 percent combined $Ta_2O_5+Cb_2O_5$ content for the Congo (Kinshasa) and averaging between 19.5 and 22 percent, combined $Ta_2O_5+Cb_2O_5$ content for Thailand was produced; quantitative data are not available. Tantalum-bearing tin slags wer also reported as being received from Brazil, Malaysia, and Nigeria; quantitative data are not available.

[7] Includes microlite (Ta_2O_5) concentrate as follows: 1964, 340,000; 1965, 189,000; 1966, 175,000; 1967, 166,000; and 1968, 198,000.

[8] Totals are of listed figures only.

ported as most of the recovery plants operated at or near their maximum capacity.[5] Much of this increase was the result of Australia's higher tin production from which tantalite was recovered as a byproduct. All tantalite production comes from operations in Western Australia.

Brazil.—As a result of the low price and decreased demand for columbium in 1968, Brazilian columbium production fell, but Brazil remained the major world producer of columbium raw materials. Companhia Brasileira de Metalúrgia e Mineracao (CBMM), the country's leading producer, continued to recover columbium concentrate from rich pyrochlore ores containing 4+ percent Cb_2O_5 at the company mine and mill at Araxá, Minas Gerais.

CBMM also continued to produce ferrocolumbium (FeCb) from these concentrates in three thermite-type batch reactors and exported all but approximately 30 tons which were consumed domestically. Because of Molybdenum Corporation of America's financial and technical interest in these operations, over half of the material exported was shipped to the United States.

Canada.—St. Lawrence Columbium and Metals Corp. produced pyrochlore concentrates from its underground mining operations and mill facilities near Oka, Quebec and continued to be Canada's sole columbium producer in 1968. In addition to producing concentrates for export, primarily to Western Europe, St. Lawrence processed some of this concentrate to ferrocolumbium for the Canadian steel market.

During the first half of the year St. Lawrence operated at about 75 percent of its rated capacity as part of a cutback policy agreed upon with Brazilian and Nigerian columbium producers. During this period the mill processed approximately 1,400 tons of ore per day of which about 50 percent came from the company's stockpiles of material mined previously by open pit techniques. The remainder came from underground operations and mill recovery was approximately 3 pounds of Cb_2O_5 per ton of ore. During the second half of the year the mill recovery rose to some 6.6 pounds of Cb_2O_5 per ton of ore, all from underground mining operations.

St. Lawrence indicated that anticipated production in 1969 would increase 25 percent over that of 1968 as the higher grade underground ore was processed.

Tantalum Mining Corporation of Canada Ltd. (TMCC), a joint venture by The Goldfield Corp. and Chemalloy Minerals Ltd., completed construction of a 500-ton-per-day mill at Bernic Lake, Manitoba, late in the year and will become Canada's first tantalum producer in 1969.[6] It is anticipated that this mill will have a recovery rate of 70 percent. TMCC's tantalite reserves have been estimated at some 2 million tons of ore averaging 0.25 percent Ta_2O_5. Design of the mill was based upon pilot-plant studies which indicated that the most efficient method of recovery was by a combination of gravity concentration and high-intensity magnetic separation processes.[7]

Pilot-plant studies of a 250-ton sample from the James Bay pyrochlore deposit were being conducted by Lakefield Research late in the year. It is expected that firm feasibility studies will be completed during 1969 and, following evaluation of the columbium concentrate by potential customers, operation of the deposit will begin early in 1970.

Congo, (Kinshasa).—Société Miniere de Lueshe (SOMILU), in which Union Carbide Corp. holds controlling interest, obtained a concession to mine the pyrochlore deposits at Lueshe and Bingo following several years of exploration to determine the grade and size of these deposits.

France.—Cie. Générale de Télégraphic sans Fil of Paris has been licensed by Kawecki Berylco Industries, Inc. as the exclusive European marketer and manufacturer of the new cryogenic columbium-tin superconducting alloys developed by the U.S. firm.

Germany, West.—Effective July 1, 1968, the columbium and tantalum activities of Ciba Rare Metals, a division of Ciba Ltd., Basle, Switzerland, were transferred to the West German metal processing firm, Hermann C. Starck, Berlin. Starck will continue the production of these columbium and tantalum products at the plant in Basle.

---

[5] Bureau of Mineral Resources, Geology and Geophysics. Australian Mineral Industry: Quarterly Review and Quarterly Statistics. Camberra, Australia, v. 21, No. 1, October 1968, 50 pp. v. 21, No. 2, December 1968, 50 pp.

[6] Howe, A. C. E. Canada's First Tantalum Producer. Western Miner, v. 41, No. 12, December 1968, pp. 39–49.

[7] Raicevic, D. Concentration of Tantalum From the Bernic Lake Pegmatite Deposit, Manitoba. Canadian Min. and Met. Bull., v. 61, No. 680, December 1968, pp. 1439–1444.

Japan.—Imports of powdered tantalum metal increased sharply during the year and totaled some 14,000 pounds compared with 6,160 pounds in 1967. About 90 percent of this material was used in capacitor production. Because domestic production of tantalum powder by the three major producers, Showa Denko, Shinetsu Chemical, and Tokyo Denkai, totals only about 2,860 pounds annually almost all of the remaining tantalum powder requirement for the rapidly growing Japanese electronics industry must be supplied by imports.

Kenya.—Prospecting and mining rights for exploitation of the Mrima Hills pyrochlore deposits were granted to the French firm Pechiney Saint-Gobain during the year. In addition to the columbium content of the ores, significant quantities of rare-earth oxides (REO) are also known to occur in this deposit. It is believed that Pechiney's prime interest is in recovering REO from this deposit which is estimated to contain approximately 7 million tons of 5+ percent rare-earth oxide material and some 35 million tons of 1.1-percent material. While existence of the deposit has been known for several years, this material has not been mined commercially because of the extreme difficulty in processing the complex ore. Recent metallurgical studies have indicated that economic methods of coproduct recovery of the mineral values (columbium and REO) from these ores are now feasible.

Mozambique.—A high-grade columbite-tantalite deposit was discovered approximately 210 miles inland from the port of Nacala and some 38 miles north of the rail line to that city. This material reportedly contains 45 percent Cb_2O_5 and 35 percent Ta_2O_5.

Nigeria.—Although the Nigerian columbite-tantalite operations are not located near the troubled Southeastern area claimed by Biafra, consumers have been reluctant to enter long-term agreements because of the country's continued political turmoil. As a result, exports of columbium-tantalum concentrates recovered as a byproduct of tin mining operations decreased during the year but were sufficient to rank Nigeria third (behind Brazil and Canada) in columbium production.

A paper by the Nigerian Chief Inspector of Mines was released which described Nigeria's potential for producing columbite and tantalite minerals and indicated that traditionally the major columbite producers were located in Plateau, Benue, Bauchi, and Kano Provinces while the major tantalum producers were located in the Provinces of Plateau, Zaria, Kabba, and Niger.[8]

South-West Africa, Territory of.—Although Tantalite Valley Minerals (Pty.) Ltd., in the Warmbad district, produces some tantalum concentrate by hand-sorting of ore recovered from underground mining operations, no large-scale mining has occurred due to bad roads, the long distance to railroad shipping facilities, and low tantalum prices.[9]

United Kingdom.—Kawecki Berylco Industries, Inc., issued a license to the Kynoch works of Imperial Metal Industries Ltd. (IMI), a subsidiary of Imperial Chemical Industries Ltd., of Birmingham, which allows IMI to be the exclusive European marketer and manufacturer of columbium- and tantalum-base alloys developed by the U.S. company for high-temperature structural applications in the aircraft, aerospace, and nuclear fields.

TECHNOLOGY

Studies of columbium and tantalum alloys suitable for high-temperature applications were continued by metallurgists of the Bureau of Mines and of 56 alloys which were investigated the Cb-Hf-W-Zr-Al-Ti-N, Cb-Hf-W-Zr, Cb-Ti-Zr-Hf, Ta-Hf-Al, and Ta-Hf-W-Al systems showed superior high-temperature strength.[10] At 1,200° C the columbium alloys had strength values of 40,000 psi (pounds per square inch) or greater, and the tantalum alloys had strength values from 50,000 to 58,000 psi.

---

[8] Ifaturoti, E. A. Nigeria's Potential For Production of New Metals and Minerals. Investor's Digest (London), June 1968, pp. 21–24.

[9] Mining Magazine (London). Tantalite Mining. V. 117, No. 6, December 1967, pp. 443–445.

[10] Babitzke, Herbert R., and Jack G. Croeni. Study of Columbium and Tantalum Alloys. BuMines Rept. of Inv. 7116, April 1968, 16 pp.

As part of further studies of alloys suitable for elevated temperature uses the Bureau also evaluated the solid solution and precipitation-hardening effects, formability, and oxidation resistance of 33 additional columbium and tantalum alloys.[11]

In other Bureau of Mines research, extractive metallurgical evaluations of columbium-tantalum minerals were conducted which indicated the optimum conditions for batch flotation of natural columbium, tantalum, and pyrochlore ores and the vapor pressure of liquid columbium was determined at elevated temperatures.[12]

The geochemistry of the world's columbium and tantalum minerals was summarized in a report by the Geological Survey.[13] This report also included a glossary of columbium and tantalum minerals.

A technical progress review of alloy development, irradiation effects, fabrication, oxidation and corrosion resistance and coating studies of columbium and tantalum and their alloys was conducted for the U.S. Atomic Energy Commission (AEC) with special emphasis on high-temperature reactor material applications.[14]

In addition to alloy development work conducted by the Bureau of Mines and the AEC, evaluation of high-temperature columbium- and tantalum-base alloys was continued by the U.S. Air Force and its contractors. A high-strength Cb-29 Hf-14 W-2 Ta-1.5 Zr-0.2 C alloy (in weight-percent) containing trace elements of hydrogen, oxygen, and nitrogen was developed which produces its own oxidation resistant coating upon exposure to the atmosphere at elevated temperatures.[15] Although only 0.03 to 0.04 inch thick the coating is sufficient to protect the columbium base alloy when subjected to the elevated temperatures encountered in aircraft turbines.

Integrated tantalum thin-film circuits, capable of high precision which make possible the manufacture of Touch-Tone telephone generators and adjustable attenuators, are experiencing a rapid rate of growth due to their high reliability, low cost, small size, and ability to tailor electronic values in normal processing to meet circuit requirements.[16]

The state of technology of refractory metal alloys, including those of columbium and tantalum, was evaluated and physical and mechanical metallurgy, reactions with gases and liquid, applications and technology, and alloy development were reviewed.[17]

---

[11] Babitzke, Herbert R., Laurance L. Oden, and Hal J. Kelly. Columbium and Tantalum Alloy Development. BuMines Rept. of Inv. 7211, December 1968, 12 pp.

[12] Fergus, Andrew J., and Gerald V. Sullivan. Microflotation Studies of Some Columbium-Tantalum Minerals. BuMines Rept. of Inv. 7189, 1968, 29 pp.

Koch, R. K., W. E. Anable, and R. A. Beall. Vapor Pressures of Liquid Columbium (2,740° to 3,140°K) and Liquid Hafnium (2,500° to 2,810°K). BuMines Rept. of Inv. 7125, 1968, 24 pp.

[13] Parker, Raymond L., and Michael Fleischer. Geochemistry of Niobium and Tantalum. U.S. Geo. Survey Prof. Paper 612, 1968, 43 pp.

[14] Simons, E. M., S. W. Porembka, Jr., and D. L. Keller. Reactor Materials. Battelle Memorial Inst., Columbus, Ohio, v. 11, Nos. 1–4, 1968, 283 pp.

[15] Materials Engineering. High Strength Columbium Alloy Coats Itself to Resist Oxidation. V. 68, No. 7, December 1968, p. 28.

[16] Priolo, Louis A., and William B. Reichard. Thin-Film Technology Enters a New Era. The Western Electric Engineer, v. 11, No. 4, December 1967, pp. 44–50.

[17] Machlin, Irving. Symposium on Metallurgy and Technology of Refractory Metal Alloys—A State-of-the-Art Review. J. Metals, v. 20, No. 9, September 1968, pp. 21–25.

Machlin, I., R. T. Begley, and E. D. Weisert (eds.). Refractory Metal Alloys—Metallurgy and Technology. Plenum Press, New York, 1968, 491 pp.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/201

Copper

By John W. Cole [1]

At the beginning of 1968 more than 90 percent of the domestic copper industry was closed by continuation of the labor strike that started in July 1967. Available refinery capacity was further reduced by 198,000 tons per year on January 20 when Kennecott Refining Corporation's Anne Arundel, Md., plant was closed by a labor strike. The strike that closed the copper producing industry was settled on a company by company basis beginning on January 25, when striking workers at the White Pine copper mine in Michigan ratified a new contract between the company and United Steelworkers of America. Full operations were resumed at most plants during April.

Legislation and Government Programs.—During the year the quantity of copper in the national stockpile was reduced 13,800 tons by Government agency withdrawals. Not including Oxygen Free High Conductivity (OFHC) copper, the total in the stockpile at yearend was 201,300 tons, 29 percent of the objective of 702,800 tons. The quantity of OFHC copper in the stockpile remained unchanged during the year at 60,100 tons, 89 percent of the objective of 67,600 tons.

On resumption of operations after settlement of the copper industry strike, export controls, administered by the Office of Export Control, and producers set asides, administered by the Business and Defense Services Administration (BDSA), both in the U.S. Department of Commerce, again become effective. Export licensing quotas for the second half were as follows:

Refined copper (domestic origin)	25,000 tons
Copper-base scrap	25,000 tons
Copper-base ingot alloys	1,500 tons
Semifabricated copper products and copper master alloys	9,000 tons
Copper ores, concentrates, matte, blister and other refined copper	closed quota
Other copper products	open-end quota

The large increase in exports of copper scrap to Canada demonstrated the ineffectiveness of export controls as long as they did not apply to Canada. Late in the year, Canada was added to the quota list and allotted a quota of 2,400 tons for 1969.

DOMESTIC PRODUCTION

PRIMARY COPPER

Mine Production.—On resumption of operations after settlement of the strike, mine production of recoverable copper in most States returned to normal in April. May's production was 126,000 tons, comparable to the monthly production in 1966 and early 1967 before the strike began. The total production for the year was 1,205,000 tons, 26 percent greater than in 1967, but 16 percent less than in 1966. However, the average monthly production during the last half of 1968 was only slightly less than the average monthly production during the first half of 1967.

The average recoverable copper content of ore declined from 0.63 to 0.60 percent, continuing the average yearly decline of 0.03 percent that has prevailed since 1964.

Recovery of precipitate copper (table 7, footnote 1) was 147,000 tons, up 14 percent from that of 1967, and equal to 14 percent of the copper recovered by other methods (12 percent of recoverable mine production).

Smelter Production.—Total output of copper at primary smelters in the United States increased 47 percent from 1967 output but was 14 percent less than in 1966. The average monthly smelter production during the last half of 1968 was 146,000 tons compared with 140,000 tons during the first half of 1967.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Salient copper statistics

	1964	1965	1966	1967	1968
United States:					
Ore produced----thousand short tons--	155,200	173,286	186,966	127,066	170,054
Average yield of copper----percent--	0.73	0.70	0.67	0.63	0.60
Primary (new) copper produced—					
From domestic ores, as reported by—					
Mines-----------short tons--	1,246,780	1,351,784	1,429,152	954,064	1,204,621
Value----------thousands--	$812,901	$957,028	$1,033,850	$729,401	$1,008,195
Smelters----------short tons--	1,301,115	1,402,806	1,429,863	841,848	1,234,724
Percent of world total------	23	23	24	14	19
Refineries---------short tons--	1,259,852	1,335,660	1,353,087	846,551	1,160,925
From foreign ores, matte, etc., as reported by refineries short tons--	396,543	376,133	357,897	286,431	276,461
Total new refined, domestic and foreign-----------short tons--	1,656,395	1,711,793	1,710,984	1,132,982	1,437,386
Secondary copper recovered from old scrap only--------------short tons--	473,521	513,436	534,860	482,659	520,772
Exports:					
Metallic copper--------short tons--	381,432	379,498	319,314	221,066	313,741
Refined-----------------do----	316,230	324,965	273,071	159,358	240,745
Imports, general:					
Unmanufactured-----------do----	586,064	523,141	594,704	649,227	709,975
Refined-----------------do----	139,974	137,443	164,328	330,571	400,278
Stocks Dec. 31: Producers:					
Refined---------------short tons--	37,000	35,000	43,000	27,000	48,000
Blister and materials in solution short tons--	246,000	246,000	270,000	220,000	272,000
Total-----------------do----	283,000	281,000	313,000	247,000	320,000
Withdrawals (apparent) from total supply on domestic account:					
Primary copper--------short tons--	1,495,000	1,526,000	1,593,000	1,320,000	1,576,000
Primary and old copper (old scrap only)---------------short tons--	1,969,000	2,039,000	2,128,000	1,803,000	2,097,000
Price: Weighted average cents per pound-	32.6	35.4	36.6	38.6	42.2
World:					
Production:					
Mine-----------------short tons--	5,297,121	5,549,074	5,800,341	5,518,602	5,893,620
Smelter-----------------do----	5,791,720	6,104,622	6,123,899	5,939,056	6,649,331
Price: London, average cents per pound-	43.88	58.52	69.04	51.19	56.13

Refinery Production.—Production of refined copper from all materials processed at primary refineries was 1,781,000 tons, up 21 percent from that of 1967. The average monthly production during the last half of 1968 was 127,000 tons compared with 121,000 tons during the first half of 1967. Refined copper produced at secondary plants was 72,000 tons compared with 62,000 tons in 1967. The total production of refined copper produced from scrap in the United States was 416,000 tons, equal to 35 percent of domestic mine production.

Of the forms cast at primary refineries wire bars constituted 59 percent, ingot and ingot bars 13 percent, and cathodes 11 percent.

Copper Sulfate.—Production of copper sulfate increased 9 percent from that of 1967, to 43,800 tons. Shipments increased 8 percent over those in 1967, and were in balance with production. Producers reports indicated that 19,000 tons was sold for agriculture uses, 24,000 tons was for industrial uses, and 1,000 tons was for other uses (chiefly exports).

Byproduct Sulfuric Acid.—Sulfuric acid produced from the sulfur contained in off-gases from copper smelters increased 38 percent from that of 1967 and 3 percent from that of 1966. Low production in 1967 was due to the copper industry labor strike.

SECONDARY COPPER AND BRASS

Recovery of copper in the United States in alloyed and unalloyed form, from all classes of purchased scrap totaled 1.22 million tons in 1968, up 5 percent from that of 1967, but 8 percent below the record set in 1966. Copper recovered in all forms from copper-base scrap at secondary smelters was up 6 percent but was about the same at primary copper producers; at brass mills, it was up 10 percent and at foundries and manufacturers it was up 4 percent.

Consumption of purchased copper-base scrap totaled 1.6 million tons, an increase of 7 percent from that of 1967. Use at secondary smelters increased 6 percent to 450,000 tons, of which 77 percent was old scrap. Primary producers used 513,000 tons, a 7-percent increase from that of 1967, and brass mill consumption rose to 595,000 tons, an increase of 10 percent. Foundries and other plants used 103,000 tons compared with 100,000 tons in 1967.

CONSUMPTION

Apparent withdrawals of primary copper totaled 1.6 million tons, up 19 percent from 1967 levels but slightly less than in 1966. Actual consumption of refined copper was 3 percent less than in 1967; from a monthly low of 95,000 tons in February it rose to 204,000 tons in October and then fell to 161,000 tons in December. Actual consumption is based on consumers reports of quantities entering processing with no adjustments for changes in stocks.

As far as possible to ascertain, only new copper is included in table 26, but table 27 does not distinguish between old and new copper, but includes all copper in refined form.

STOCKS

Primary producers stocks of refined copper dropped from a yearend 1967 low of 27,000 tons to 25,000 tons at the end of March. On resumption of operations in April after settlement of the labor strike, stocks rose gradually to 52,000 tons at the end of November and were 48,000 tons at yearend 1968. Unrefined copper stocks started the year at a low of 220,000 tons, rose to 312,000 tons in August and finished the year at 272,000 tons.

Fabricators stock of refined copper, including in-process metal and primary fabricated shapes, were 514,500 tons at yearend, 7 percent greater than at the beginning of the year. Working stocks inventory increased 4,400 tons during the year.

PRICES

The domestic price for primary copper remained at 38 cents per pound during the first 2 months of 1968. During the last week in March, Phelps Dodge Corp. and The Anaconda Co. raised their selling price to 42 cents per pound. Kennecott Copper Corp. raised its price on electrolytic wire bars to 42¼ cents on April 2 and American Smelting and Refining Co. followed with a similar raise. The new prices continued unchanged at yearend.

The New York price for No. 1 scrap was 44 to 45 cents per pound in January. After rising to 48 cents in February and early March, it declined to 29.5 to 30.5 cents on June 1. The price firmed later in the year and was quoted at 39 to 40 cents per pound at yearend.

The London Metal Exchange spot price for copper wire bar averaged 64.1 cents per pound in January. After raising to the year high of 78.2 cents in February, it fell to 47.6 cents in July and closed the year at 53.4 cents per pound in December.

FOREIGN TRADE

U.S. exports of copper in ore, concentrate, and matte amounted to 65,000 tons, up 67 percent from those of 1967, but exports of blister copper declined from 21,000 tons in 1967 to 16,000 tons. On resumption of copper industry operations in April, export licensing regulations were tightened and the monthly exports dropped to less than 500 tons per month in July and remained low except for November (6,000 tons) and December (1,000 tons) when they were higher owing to contract commitments made during the strike. Exports of refined copper and semimanufactures were 298,000 tons, up 49 percent from those of 1967 but 7 percent less than in 1966.

Exports of copper-base alloy were up 25

percent to 99,000 tons; exports of unalloyed copper scrap were 34,000 tons, an increase of almost 100 percent from those of 1967; and exports of copper alloy scrap were 86,000 tons, up 32 percent from 1967 levels.

U.S. imports of copper (unmanufactured) were 710,000 tons, an increase of 9 percent from those of 1967. Chile supplied 181,000 tons, Canada 151,000 tons, and Peru 112,000 tons amounting to 63 percent of the total, compared with 70 percent of the total in 1967 from the same three countries. Imports for consumption of copper in ore and concentrate were 72,000 tons, up 100 percent from those of 1967 and 10 times the same class of imports in 1966. Principal countries of origin for copper in ore and concentrate were the Philippines, Canada, and Peru in order of quantities received. Imports for consumption of refined copper were 404,000 tons, up 21.6 percent from those of 1967, and up 400 percent from those of 1966. Imports for consumption of blister copper were up slightly from those of 1967 but were 19 percent below 1966 levels. Imports for consumption of unalloyed copper scrap, principally from Canada were 11,600 tons, down 30 percent from 1967 levels.

WORLD REVIEW

The United States continued to lead the world in mine and smelter production of copper, producing 22 and 19 percent, respectively. The Soviet Union was second, Zambia was third, and Chile was fourth with estimated 15, 12, and 12 percent, respectively, of world mine production. The Philippines registered the greatest increase (34 percent) in production from 1967 levels and Peru was second (18 percent).

Australia.—Australia's mine production of copper was 117,000 tons, up 17 percent from that of 1967. Mount Isa Mines Ltd., 53 percent owned by American Smelting and Refining Company produced 53,900 tons of copper in the year ended June 30, 1968, down from 58,000 tons in the previous year.

Austria.—The Union Corporation Ltd., Republic of South Africa, entered into an agreement with the Austrian Government-owned Kupferbergbau-Mitterberg G.m.b.H. to conduct exploration at the latter's old and inoperative copper mine at Rohrerbeuhel, Kitzbuehel, Tyrol. The Government owned corporation is working the only existing copper mine in Austria, near Muehlbach, Salzburg. This mine produces about 2,000 tons of copper per year approximately 10 percent of Austria's requirements.

Canada.—Canadian mine production of copper increased about 1 percent from that of 1967. Production in Ontario increased 5 percent of 288,000 tons;[3] this amounted to 47 percent of Canadian copper production. Production of copper in Quebec decreased 6 percent to 156,000 tons, and equaled 25 percent of Canadian production. Copper production in British Columbia, the third ranking producer, decreased 5 percent to 82,000 tons, equal to 13 percent of Canadian copper production.

In its first full year of mine production, Ecstall Mining Ltd., subsidiary of Texas Gulf Sulphur Company, produced 205,400 tons of 23-percent-copper concentrates, 562,000 tons of 52-percent-zinc concentrates, and 96,000 tons of lead concentrates from the Kidd Creek mine near Timmins, Ontario. The silver content of the concentrates was 13.4 million ounces. More than 3.6 million tons of ore was mined by open-pit methods and milled in a flotation plant. Preliminary studies were made to develop an underground mine to supplement open-pit mining. Mitsubishi Metal Mining Co. Ltd. agreed to extend a $16.4 million loan to Sherritt Gordon Mines Ltd. to help finance development of the Fox copper ore deposits in Manitoba. Repayment of the loan would be in 25 percent copper concentrates at the rate of 1,700 tons of contained copper per year for 10 years, starting in 1971.

Interest in exploration and development of copper mines for the future continued in British Columbia. Granduc Operating Co. completed driving a 10.3-mile tunnel to reach the copper orebody at the Granduc mine in the Portland Canal area, northwest British Columbia. In a joint venture, Granduc Operating Co., a wholly owned subsidiary of Newmont Mining Corp., together with American Smelting and Refining Co. leased the mine from Granduc

---

[3] Killan, A. F. The Canadian Mineral Industry in 1968, Preliminary. Dept. Mines and Tech. Surveys, Miner. Res. Div. (Ottawa, Canada), Miner. Inf. Bull. MR 97, 1969, pp. 25–31.

Mines Ltd., and are developing the mine and building all facilities to bring it into operation. It is expected to be in production late in 1969 at the rate of 7,000 tons of ore per day.

Although a study by a consulting firm demonstrated the economic feasibility of working Lornex Mining Corporation's low-grade copper-molybdenum property in the Highland Valley area of British Columbia, Rio Algom Mines had not reached a decision at yearend about bringing the property into production. Rio Algom Mines Ltd. is a 51-percent-owned subsidiary of Rio Tinto-Zinc Corp. Ltd. The Lornex orebody is reported to contain 293 million tons of ore averaging 0.427 percent copper and 0.014 percent molybdenum.

Bethlehem Copper Corporation Ltd. milled 4.1 million tons of ore and produced 20,000 tons of copper, 25 percent more than in 1967. Exploratory drilling in the Huestis zone indicated 25 million tons of 0.65-percent-copper ore with the western limits not defined. Core drilling on Valley Copper Mines property adjoining Bethlehem property on the west by Cominco, Ltd., which has a 64-percent interest in the property, indicates there may be a large undeveloped copper orebody under the two properties.

Newmont Mining Corp. completed drilling its Ingerbelle copper deposit. Ore reserves are estimated at 43.5 million tons averaging 0.56 percent copper. Newmont agreed to purchase the adjoining Copper Mountain property from Granby Mining Co. Ltd. for 40,000 shares of Newmont stock and $8 million cash.

Utah Construction & Mining Co. has outlined by drilling an orebody near Port Hardy, Vancouver Island, that is estimated to contain 180 million tons of ore averaging 0.52 percent copper and 0.025 percent molybdenum sulfide. A test shaft has been sunk to a depth of 200 feet and over 1,100 feet of drifts and crosscuts have been driven. Bulk samples have been shipped to Utah Construction's pilot plant at Cedar City, Utah, for milling tests.

Chile.—Although drought conditions caused a cut in production at the El Teniente mine from 200,000 short tons in 1967 to 170,000 tons in 1968 and labor strikes caused a decrease in production at Chuquicamata in April and May, the total mine production of copper in Chile was less than 2,000 tons under that of 1967.

A new copper refinery at Chuquicamata inaugurated late in the year will increase capacity of refined copper from 227,000 to 426,000 tons per year.

Additional financing for the Rio Blanco copper mine project was arranged by Cerro Corp. and Corporación del Cobre (Codelco). Estimates of the capital cost of developing the mine have increased about 80 percent over 1966 estimates. Compañía Minera Andina S.A., owned 75 percent by Cerro and 25 percent by Codelco is providing the additional financing. Under the new financing agreement, Cerro Corporation's share in Compañía Minera Andina will decrease to 70 percent and Codelco's share will increase to 30 percent.

Agreement was reached between Continental Copper & Steel Industries, Inc., and Cía Anonima Cuprifera de Sagasca, a 98-percent-owned subsidiary, and the Chilean Government for development of the Sagasca copper mine in northern Chile. Planned to produced 27,000 tons of copper per year starting in 1970; the capital investment is estimated at $32.5 million.

A reserve of 17 million tons of ore averaging 2.16 percent copper has been established by core drilling. Japanese copper smelting companies, including Dowa Mining, Mitsui Mining and Smelting, and Mitsubishi Metal Mining, have agreed to loan $10 million to Continental Copper & Steel Industries, Inc., as part of the capital required, in return for 24,000 tons per year of copper concentrates over a period of 6 years starting in 1970.

International Telephone and Telegraph Corporation announced plans to provide up to $80 million for exploration and development of copper mines in Chile.

Congo (Kinshasa).—Société Générale Congolaise des Minerais (GECOMIN), the Government-owned company that now is operating the large mining complex expropriated from Union Minière, produced 357,600 tons of copper in 1968 compared with 351,000 tons in 1967 and 346,600 in 1966.

Copper deposits estimated to contain 30 million tons averaging 3.3 percent copper are reported to have been found about 25 miles southeast of Elisabethville in Katanga province. Discovery came as a result of prospecting by a Japanese consortium known as Sodimiko formed for this purpose following Nippon Mining's agreement with the Congolese for a mining concession. The consortium comprised Nippon Mining Co., Ltd., Mitsui Mining & Smelting Co. Ltd., Sumitomo Metal Mining Co. Ltd., Furukawa Mining, Toho Zinc Co. Ltd., and the trading company Nissho. Production is planned to begin in 1970 at the rate of 5,000 tons of ore per day to yield 40,000 tons per year of copper in concentrates which will be transported 1,200 miles by rail to Beira in Mozambique for shipment to Japan.

Cyprus.—In 1968 the Cyprus Island Division of Cyprus Mines Corp. shipped 37,400 tons of copper concentrates containing approximately 18 percent copper in addition to production of pyrite and cupreous pyrite. A new zone of copper mineralization was delineated near the Skouriotissa pit which contains about 20 million tons averaging 0.58 percent copper.

Japan.—Nippon Mining Ltd. announced plans to build a new flash smelting furnace with a daily charge rate of 1,320 tons of copper concentrate, at its Saganoseki smelter on Kyushu. The new furnace will have an annual capacity of 120,000 tons of copper

Plans were completed for erection of Japan's eighth copper refinery by Mitsui Mining & Smelting Co. Ltd. and Nittesu Mining Company. The new plant, to be located at Hibi, Okayama Prefecture, is expected to produce 5,0000 tons per month of refined copper starting in 1970.

Mexico.—Asarco Mexicana, S.A., produced 23,300 tons of blister copper compared to 19,300 tons in 1967. Asarco Mexicana is developing its Inguaran copper property in the State of Michoacan. Ore reserves total 4.4 million tons averaging 2 percent copper and 0.3 ounce of silver per ton. Construction of a plant to mine and mill 2,200 tons per day is estimated to take 2 to 3 years. Asarco Mexicana is conducting an exploration program on La Caridad property near Nacozari in the State of Sonora. Should feasibility of developing a mine be established Asarco Mexicana has an option to acquire a 49-percent interest and to manage the property. Forty-nine percent of Asarco Mexicana, S.A., is owned by American Smelting and Refining Company (ASARCO). Compañia Minera de Cananea, S.A. de C.V., produced 36,500 tons of copper compared with 35,500 tons in 1967.

Peru.—Peru's 1968 production of copper was 235,000 tons, 35,000 tons greater than in 1967, the largest tonnage increase of any of the copper producing countries. The percentage increase (18 percent) was second only to that of the Philippines. A substantial part of the increase was credited to the first full year's production from the Cobriza copper mine of Cerro de Pasco Corp. The Cobriza mine, situated in the District of Coris, Province of Tayacaja, Department of Huancavelica, at an altitude of about 6,000 feet is the first highly mechanized underground mine in Peru. Ore reserves have been estimated at 7.5 million tons containing 2 percent copper and 0.45 ounce per ton of silver. The concentrator capacity is 1,000 tons per day.

Negotiations continued between the Peruvian Government and the Southern Peru Copper Corp. for development of the Cuajone copper mine, and Andes del Peru, subsidiary of The Anaconda Company, for development of the Cerro Verde copper property. The Cuajone copper deposits are estimated to contain 500 million tons of ore containing a little over 1-percent copper. Under present plans for an operation that would treat 30,000 tons per day of copper ore and produce 150,000 tons per year of copper, $335 million investment and 4 to 5 years' time would be required for development. The Cerro Verde orebody is estimated to contain 140 million tons of mixed oxide and sulfide ore grading a little over 1-percent copper. An initial investment of $30 to $35 million will be required to develop the mine and build a leaching plant for treatment of oxide ore.

Philippines.—The Philippines registered the largest percentage increase (34 percent) in mine production of copper and produced 126,000 tons of copper in concentrates. The increase was due principally to expanded production by Lepanto Consolidated Mining Co. Ltd., Atlas Consolidated Mining & Development Co., and Marinduque Mining and Industrial Corp.

Marcopper Mining Corp., a Philippine corporation owned 60 percent by the Philippine Government and 40 percent by Craigmont Mines Ltd., a subsidiary of Placer Development, Ltd., is developing an open-pit copper mine on Marinduque island with first production scheduled for 1970. The initial milling rate will be 15,000 tons of ore per day. For a period of 10 years, Nippon Mining Co. has contracted to purchase all concentrates produced for smelting in Japan.

South Africa, Republic of.—Palabora Mining Co., Ltd. produced 79,433 short tons of copper and sold 81,408 tons compared with 84,370 and 84,370 tons, respectively in 1967. Ore milled in 1968 was 15.7 million tons compared with 14.6 million tons in 1967, but the average grade in 1968 was 0.64 percent copper compared with 0.71 percent in 1967.

O'okiep Copper Co. Ltd. produced 41,441 tons of blister copper and sold 47,166 tons in 1968 compared with 42,529 tons and 43,405 tons, respectively, in 1967. The total ore milled (3.2 million tons) was the same as in 1967, but the average grade of ore dropped from 1.55 to 1.44 percent copper.

South-West Africa.—The Tsumeb mine and mill of Tsumeb Corp., Ltd., mined and milled 634,303 tons of complex sulfide and oxide ore averaging 4.57 percent copper, 10.30 percent lead, and 2.99 percent zinc, and 2.13 ounces per ton of silver. The Kombat operation mined and milled 323,624 tons of ore averaging 2.86 percent copper, 1.31 percent lead, and 0.48 ounce per ton of silver. Blister copper produced was 35,706 tons, little changed from that of 1967.

Spain.—The Cerro Colorado concession, near Huelva, owned by Rio-Tinto Patiño, has been estimated to contain 42.3 million tons of 0.92-percent-copper ore available for open-pit mining. Rio-Tinto Patiño, a joint venture of Compañía Española de Minas de Rio-Tinto (55 percent), The Patiño Mining Corp. (40 percent), and Rio-Tinto Zinc Investment, Ltd. (5 percent), has started construction of a $20 million copper smelter with an initial capacity of 40,000 tons per year.

Sweden.—The Boliden Mining Co., Ltd. started open-pit mining at its Aitik copper deposit in Arctic Sweden. Mining will be at the rate of about 2 million tons of ore per year of 0.5-percent-copper ore to yield about 10,000 tons per year of copper. The company's copper smelting works at Rönnskär is being expanded from 50,000 tons to 60,000 tons per year presumably to smelt the additional concentrates from Aitik.

Uganda.—Kilembe Mines Limited in which Falconbridge Nickel Mines Limited holds a 72.8-percent interest, produced 15,000 tons of blister copper in 1968, an increase of 7 percent over 1967 levels.

Zambia.—During the year, three of the Roan Selection Trust Ltd. (RST) group of companies were reorganized into one company with three operating divisions. (RST interest in new company is 64.81 percent.) Chibuluma Mines Ltd. and Chambishi Mines Ltd. were liquefied voluntarily and the Chibuluma, Chambishi, and Mufulira mines are now operated as divisions of Mufulira Copper Mines Ltd.

The Luanshya mine, previously operated as a division of RST, was acquired April 1, 1968, by Luanshya Mines Ltd., a wholly owned subsidiary of RST.

The Mufulira mine produced 181,000 tons of copper compared with 133,000 tons in the previous year. The Chibuluma mine produced 27,000 tons, up from 21,000 tons in 1967. The Chambishi mine produced 22,000 tons of copper compared with 15,000 in 1967. Luanshya Mines Ltd. produced 107,000 tons of copper compared with 86,000 tons in 1967.

The Rhokana Corporation Ltd., subsidiary of Anglo American Corporation (Central Africa) Ltd., owns substantial interests in Nchanga Consolidated Copper Mines Ltd., and Bancroft Mines Ltd., as well as in the RST administered companies (except Luanshya Mines Ltd.). For the year ended March 1968, Nchanga produced 226,000 tons of copper, up from 209,000 tons in 1967. Bancroft produced 51,000 tons of copper. A loan agreement was concluded in May 1968 between Nchanga Consolidated Copper Mines Ltd., and Mitsui and Co. Ltd. and Mitsubishi Shoji Kaisha Limited whereby the latter two will loan the former $42 million plus a credit guarantee of $28 million for the purchase of Japanese plant and equipment. The loans and the credit facility are repayable in the form of copper over a 7-year period. The loans will be used for expansion of Nchanga's mining operations.

TECHNOLOGY

The Kalamazoo copper orebody near the San Manuel mine was discovered by application of basic geological methods[3] although a later geochemical survey was found to roughly outline the surface projection of the orebody.

It was recognized early in development of the San Manuel orebody that a part of the orebody may have been faulted to an unknown location by the San Manuel fault. An exploration project initiated by Quintana Minerals Corporation in 1965 resulted in discovery of the faulted segment. It had moved downdip some 8,000 feet along the San Manuel fault where it was discovered by rotary drilling at a depth of about 2,500 feet below the surface.

Geophysical methods, principally induced polarization and electromagnetic, have assisted in discovery of large, low-grade copper deposits.[4] Electromagnetic methods aided in outlining the sulfide zone of the Newman deposit of Noranda Mines Ltd. on the Newman peninsula of Babine Lake. The anomaly was much more pronounced at 1,800 than at 480 cycles per second. The induced polarization method was applied successfully to outline the Brenda copper-molybdenum orebody.

Developments of the White Pine Copper Co. mine dominated the underground mining technology. An 18-foot-diameter boring machine started a 9,000-foot development tunnel.[5] Excavation will be about 50 feet below the lower ore horizon in the Copper Harbor sandstone as determined by previous core drilling. At intervals the azimuth of the tunnel heading will be adjusted to maintain the specified depth below the orebody. Boring head rotation is achieved through gearing from six 250-horsepower, 4,160-volt motors. A maximum thrust of 150 million pounds is provided by four 12-inch hydraulic cylinders having a 48-inch stroke. Gripper pressure against the sides of the bore hold is 2.25 million pounds. In operation, the boring machine is scheduled to advance development openings at the rate of 1,000 feet per month. Structurally, the machine is capable of changing direction in a curve having a minimum of 100-foot radius. Boring alinement will be maintained by operator adjustment of machine support cylinders as indicated by the mirror-reflected image of a gas laser beam.

Extensive Bureau of Mines technologic research was started on the recovery of copper from ores and secondary materials. Processes under investigation range from mineral recovery from ore and tailings, through smelting and refining. The purpose of the copper program is to increase the quantity of copper recovered from ores now being mined and to increase reserves of copper in ore.

The Anaconda Company dedicated a new research center at Tucson, Ariz. The center is a multimillion-dollar facility situated 10 miles southeast of Tucson on a 70-acre tract. Facilities consist of a laboratory and administrative building with 40,000 square feet of floor space, a multipurpose pilot plant, and a well with a 250,000-gallon water storage capacity.

The segregation process, discovered accidentally in 1923, has been reactivated by engineers of the Anglo American Corporation of South Africa, Ltd. Named TORCO[6] for "Treatment of Refractory Copper Ores," the process uses a FluoSolids reactor for heating the ore and a reaction (segregation) chamber. Copper oxide ore, heated to about 850° C in the reactor, overflows into the segregation chamber where it is mixed with charcoal and sodium chloride. Copper chloride is volatilized and reacts with the charcoal to produce metallic copper which is easily recovered by flotation. Anglo American Corp. plans to use the process in treating copper ore from a deposit near Akjoujt, Mauritania.

Final design for the Akjoujt plant will be based on successful commercial operation by Anglo American of a 500-ton-per-day plant in Zambia since 1965.

Treatment of oxide copper ore from Gaspé Copper Mines Limited Copper

---

[3] Lowell, David J. Geology of the Kalamazoo Orebody, San Manuel District, Arizona. Econ. Geol., v. 63, No. 6, September–October 1968, pp. 645–654.

[4] Fountain, David K. Geophysics Applied to the Exploration and Development of Copper and Molybdenum deposits in British Columbia. Canadian Min. and Met. Bull., v. 61, No. 678, October 1968, pp. 1199–1206.

[5] Skillings' Mining Review. Future Versus Present Underground Mining Methods and Systems at the White Pine Copper Co. Mine. V. 57, No. 29, July 20, 1968, pp. 8–11.

[6] Pinkney, E. T., and N. Plint. Treatment of Refractory Copper Ores by the Segregation Process. AIME Min. Trans. Quart., v. 241, No. 2, June 1968, pp. 157–192.

Mountain deposit, Murdockville, Quebec,[7] was investigated. The leach-precipitation-float (LPF) process was compared with Agitated Tank Leaching and Percolation Leaching. Attempts to use chalcopyrite concentrates in the place of iron in the LPF process were not successful principally because recoveries of copper in the subsequent flotation were not high enough. However, chalcopyrite concentrates can be used to precipitate copper from clear leach solutions.

Kennecott Copper Corp. was building a new plant at Ray, Ariz., designed to leach copper silicate ores from the Ray open-pit mine. The process consists of a vat leaching system designed to treat 10,000 tons of copper silicate ore per day. Sulfuric acid from the Hayden smelter will be used to leach the copper and which will be recovered from the leach solution by electrolysis.

Copper leaching practices in the western United States[8] and copper hydrometallurgy[9] were described. The Bluebird leach-electrolytic plant of Ranchers Exploration and Development Co. is the first to apply commercially the process of concentrating and purifying copper sulfate solutions by solvent extraction.

An oxygen plant was under construction to supply the Utah smelter of Kennecott Copper Corp. with oxygen for use in the copper converters. Capacity of the converters will be increased and concentration of sulfur dioxide in the off-gases will be higher. Production of sulfuric acid from the gases thus will be facilitated.

A report to the Copper Development Association (CDA) by Authur D. Little, Inc., covering a survey of materials used in water desalting plants[10] indicated that copper alloys give the best performance of materials used.

Developed in research sponsored by the International Copper Research Association, the closest approach to "stainless" copper is a copper-aluminum-tin composition that may be polished to a noncorrosive, high, gold-like luster.[11] The new alloy is being field tested for bath and kitchen fittings, decorative housewares, cutlery, tableware, and other uses.

Financed by the Edison Electric Institute and the Tennessee Valley Authority in the amount of $1,050,000, the General Electric Research and Development Center will explore the technical and economic feasibility of using cryogenic underground cable to transmit electric power. The 3-year project is part of a $17 million underground transmission research program of the Electric Research Council (ERC) which is composed of representatives from the various segments of the electric power industry.

Considerable research on removal of copper from ferrous scrap was done in Bureau of Mines laboratories and by other organizations. Copper cementation in a rotating drum using automobile scrap as a precipitant was examined.[12] Although power is required to rotate the drum, the faster precipitation and continuous recovery of copper are advantages of the tumbler method. When the relative cost of automobile scrap compared with cost of detinned shredded cans is considered, the tumbler process is competitive with the launder method.

Two complementary reports on copper removal from ferrous scrap by thermal treatment were published.[13] In both bases copper removal depended on embrittlement of the copper which was then jarred loose from the ferrous scrap. The latter report states that bare copper can be embrittled by contact with waterglass ($Na_2Si_4O_9$) prior to thermal treatment.

Considerable interest was aroused by the method of immersing a mixture of ferrous and copper scrap in molten barium chloride heated above the melting point of copper,[14] wherein the copper is melted and sinks to the bottom of the molten salt.

---

[7] Bryce, D. M., D. G. Cevigo, and P. H. Jennings. Percolation and Agitation Leaching of an Oxidized Copper Ore. Canadian Min. and Met. Bull., v. 61, No. 672, May 1968, pp. 641–645.

[8] Sheffer, Herman W., and LaMar G. Evans. Copper Leaching Practices in the Western United States. BuMines Inf. Circ. 8341, 1968, 57 pp.

[9] Cooper, Franklin D. Copper Hydrometallurgy. A Review and Outlook, BuMines Inf. Circ. 8394, 1968, 18 pp.

[10] Steel. V. 163, No. 18, Oct. 28, 1968, p. 72d.

[11] Materials Engineering. V. 67, No. 5, May 1968, p. 31.

[12] Dean, Karl C., Rees D. Groves, and Sherman L. May. Copper Cementation Using Automobile Scrap in a Rotating Drum. BuMines Rept. of Inv. 7182, 1968, 12 pp.

[13] Brown, R. R., and F. E. Block. Copper Removal From Steel Scrap by Thermal Treatment; Feasibility Study. BuMines Rept. of Inv. 7218, 1968, 15 pp.

Elger, Gerald W., Willard L. Hunter, and C. E. Armantrout. Removal of Nonferrous Metals from Synthetic Automobile Scrap on Heating in a Rotary Kiln. BuMines Rept. of Inv. 7210, 1968, 17 pp.

[14] Leak, Vance G., and M. M. Fine. An Improved Method for Separating Copper and Steel From Copper—Containing Ferrous Scrap. Secondary Raw Materials, v. 6, No. 7, July 1968, pp. 27–29.

Table 2.—Copper produced from domestic ores, by sources

(Thousand short tons)

Year	Mine	Smelter	Refinery
1964	1,247	1,301	1,260
1965	1,352	1,403	1,336
1966	1,429	1,430	1,353
1967	954	841	847
1968	1,205	1,235	1,161

Table 3.—Copper ore and recoverable copper produced, by mining methods

(Percent)

Year	Open pit		Underground	
	Ore	Copper [1]	Ore	Copper [2]
1964	82	75	18	25
1965	84	77	16	23
1966	85	80	15	20
1967	85	83	14	17
1968	87	82	13	18

[1] Includes copper from dump leaching.
[2] Includes copper from in-place leaching.

Table 4.—Mine production of recoverable copper in the United States, by months

(Short tons)

Month	1967	1968
January	122,498	28,024
February	117,887	28,034
March	132,977	41,080
April	131,996	110,936
May	130,444	125,538
June	121,911	124,635
July	66,536	123,559
August	33,001	127,903
September	24,893	121,822
October	23,675	129,833
November	24,323	124,018
December	23,923	124,739
Total	954,064	1,204,621

Table 5.—Mine production of recoverable copper in the United States, by States

(Short tons)

State	1964	1965	1966	1967	1968
Alaska	11	32	[1] 2,545	[2] 2,766	[3] 3,428
Arizona	690,988	703,377	739,569	501,741	627,961
California	1,035	1,165	1,078	788	1,182
Colorado	4,653	3,828	4,237	3,993	3,451
Idaho	4,666	5,140	4,961	4,210	3,525
Maine	----------	----------	----------	----------	(3)
Michigan	69,040	71,749	73,449	58,458	74,805
Missouri	2,059	2,331	3,913	3,215	5,494
Montana	103,806	115,489	128,061	65,483	69,480
Nevada	67,272	71,332	78,720	50,771	77,218
New Mexico	86,104	98,658	108,614	75,008	90,769
Oklahoma	----------	[4] 282	(1)	(2)	(3)
Oregon	15	(4)	(1)	----------	(3)
Pennsylvania	3,614	4,354	3,178	4,401	4,850
Tennessee	13,889	14,823	15,410	14,600	14,196
Utah	199,588	259,138	265,383	168,609	228,245
Washington	35	30	34	21	22
Wyoming	5	6	----------	----------	----------
Total	1,246,780	1,351,734	1,429,152	954,064	1,204,621

[1] Alaska, Oklahoma, and Oregon combined to avoid disclosing individual company confidential data.
[2] Alaska and Oklahoma combined to avoid disclosing individual company confidential data.
[3] Alaska, Maine, Oklahoma and Oregon combined to avoid disclosing individual company confidential data.
[4] Oklahoma and Oregon combined to avoid disclosing individual company confidential data.

Table 6.—Twenty-five leading copper-producing mines in the United States in 1968, in order of output

Rank	Mine	County and State	Operator	Source of copper
1	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper ore, copper precipitates, gold-silver ore.
2	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Do.
3	Chino	Grant, N. Mex	Kennecott Copper Corp	Copper ore, copper precipitates.
4	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
5	White Pine	Ontonagon, Mich	White Pine Copper Co	Do.
6	Pima	Pima, Ariz	Pima Mining Co	Do.
7	New Cornelia	do	Phelps Dodge Corp	Copper, gold-silver ores.
8	Ray Pit	Pinal, Ariz	Kennecott Copper Corp	Copper ore, copper precipitates.
9	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
10	Copper Queen-Lavender Pit.	Cochise, Ariz	Phelps Dodge Corp	Copper ore, copper precipitates.
11	Yerington	Lyon, Nev	The Anaconda Company	Copper ore.
12	Mission	Pima, Ariz	American Smelting and Refining Co	Do.
13	Inspiration	Gila, Ariz	Inspiration Consolidated Copper Co	Copper ore, copper precipitates.
14	Mineral Park	Mohave, Ariz	Duval Corp	Do.
15	Silver Bell	Pima, Ariz	American Smelting and Refining Co	Do.
16	Esperanza	do	Duval Corp	Do.
17	Veteran Pit	White Pine, Nev	Kennecott Copper Corp	Copper ore.
18	Butte Hill Copper Mines.	Silver Bow, Mont	The Anaconda Company	Copper ore, copper precipitates.
19	Bagdad	Yavapai, Ariz	Bagdad Copper Corp	Do.
20	Copper Cities	Gila, Ariz	Miami Copper Co	Do.
21	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
22	Copperhill	Polk, Tenn	Tennessee Copper Co	Copper-zinc ore.
23	Copper Canyon	Lander, Nev	Duval Corp	Copper ore.
24	Christmas	Gila, Ariz	Inspiration Consolidated Copper Co	Do.
25	Miami	do	Miami Copper Co	Copper precipitates.

Table 7.—Copper ore sold or treated in the United States in 1968, with copper, gold, and silver content in terms of recoverable metals [1]

State	Ore sold or treated (thousand short tons)	Recoverable metal content				Value of gold and silver per ton of ore
		Copper		Gold (troy ounces)	Silver (troy ounces)	
		Thousand pounds	Percent			
Arizona	101,294	1,146,314	0.57	89,419	4,697,394	$0.13
California	(2)	16	9.64	40	581	33.52
Colorado	1	52	1.84	6	2,324	3.74
Idaho	32	1,270	1.96	791	2,967	1.16
Michigan	8,027	149,610	.93	---------	472,813	.13
Montana	10,080	121,108	.60	9,769	1,456,742	.35
Nevada [3]	13,320	148,966	.56	36,004	424,336	.17
New Mexico	6,697	102,577	.77	4,931	114,766	.07
Tennessee [4]	1,624	28,392	.87	140	89,525	.12
Utah [3]	28,766	351,782	.61	264,731	2,254,482	.53
Washington	(2)	10	20.63	29	83	54.88
Other States	212	5,060	1.19	3	16,328	.17
Total [5]	170,054	2,055,157	.60	405,863	9,532,341	.21

[1] Excludes copper recovered from precipitates (dump and in-place leaching) as follows: Arizona 106,604,800 pounds, Idaho 99,500 pounds, Montana 17,646,800 pounds, New Mexico 76,427,100 pounds, Nevada 5,380,800 pounds, Utah 87,730,600 pounds.
[2] Less than ½ unit.
[3] Includes minor amount of tailings.
[4] Copper-zinc ore.
[5] Data may not add to total shown because of independent rounding.

Table 8.—Copper ore concentrated in the United States, in 1968, with content in terms of recoverable copper[1]

State	Ore concentrated (thousand short tons)	Recoverable copper content	
		Thousand pounds	Percent
Arizona	101,046	1,132,196	.56
Colorado	1	49	1.82
Idaho	31	1,127	1.81
Michigan	8,027	149,610	.93
Montana	10,068	120,144	.60
Nevada [2]	13,238	145,450	.55
New Mexico	6,657	102,540	.77
Tennessee [3]	1,624	28,392	.87
Utah [2]	28,766	351,752	.61
Other States	212	5,056	1.19
Total [4]	169,671	2,036,316	.60

[1] Includes all methods of concentration: "Dual process" (leaching followed by flotation concentration); LPF (leach-precipitation-flotation); tank of vat leaching; heap leaching; and froth flotation.

[2] Includes minor amount of tailings.

[3] Copper-zinc ore.

[4] Data may not add to totals shown because of independent rounding.

Table 9.—Copper ore shipped to smelters in the United States in 1968, with content in terms of recoverable copper

State	Ore shipped to smelters		
	Short tons	Recoverable copper content	
		Pounds	Percent
Arizona	248,228	14,117,700	2.84
California	84	16,200	9.64
Colorado	47	2,400	2.55
Idaho	1,259	143,900	5.71
Montana	11,349	963,500	4.24
Nevada	82,272	3,515,700	2.14
New Mexico [1]	39,940	36,600	.05
Utah	108	30,800	14.26
Washington	24	9,900	20.63
Other States	18	3,600	10.00
Total	383,329	18,840,300	2.46

[1] Primarily smelter fluxing material.

Table 10.—Copper ores produced in the United States, and average yield in copper, gold, and silver

Year	Smelting ores		Concentrating ores		Total				
	Thousand short tons	Yield in copper, percent	Thousand short tons [1]	Yield in copper, percent	Thousand short tons [1]	Yield in copper, percent	Yield per ton in gold, ounce	Yield per ton in silver, ounce	Value per ton in gold and silver
1964	553	3.20	149,835	0.72	155,200	0.73	0.0028	0.074	$0.19
1965	625	2.43	172,662	.70	173,286	.70	.0033	.074	.21
1966	549	2.34	[2] 186,417	.66	186,966	.67	.0029	.071	.19
1967	303	2.52	[2] 126,763	.63	127,066	.63	.0025	.066	.19
1968	383	2.46	[2] 169,671	.60	170,054	.60	.0024	.056	.21

[1] Includes some ore classed as copper-zinc and minor amount of tailings.

[2] Includes all methods of concentration: "Dual process" (leaching followed by flotation concentration), LPF (leach-precipitation-flotation), tank or vat leaching, heap leaching, and froth flotation.

Table 11.—Copper produced by primary smelters in the United States

(Short tons)

Year	Domestic	Foreign	Secondary	Total
1964	1,301,115	37,318	88,365	1,426,798
1965	1,402,806	31,244	93,895	1,527,945
1966	1,429,863	36,573	114,671	1,581,107
1967	841,343	20,997	70,746	933,086
1968	1,234,724	31,754	84,821	1,351,299

Table 12.—Primary and secondary copper produced by primary refineries in the United States

(Short tons)

	1964	1965	1966	1967	1968
PRIMARY					
From domestic ores, etc.:[1]					
Electrolytic	1,139,494	1,200,532	1,218,918	754,175	1,013,246
Lake	62,598	71,241	69,126	54,004	78,304
Casting	57,760	63,887	70,043	38,372	69,375
Total	1,259,852	1,335,660	1,353,087	846,551	1,160,925
From foreign ores, etc.:[1]					
Electrolytic	371,008	332,593	321,302	258,473	219,726
Casting and best select	25,540	43,540	36,595	27,958	56,735
Total refinery production of primary copper	1,656,395	1,711,793	1,710,984	1,132,982	1,437,386
SECONDARY					
Electrolytic [2]	276,954	368,232	409,986	318,709	327,549
Casting	23,172	19,879	27,977	24,568	15,869
Total secondary	300,126	388,111	437,963	343,277	343,418
Grand total	1,956,521	2,099,904	2,148,947	1,476,259	1,780,804

[1] The separation of refined copper into metal of domestic and foreign origin is only approximate, as accurate separation is not possible at this stage of processing.

[2] Includes copper reported from foreign scrap.

Table 13.—Copper cast in forms at primary refineries in the United States

	1967		1968	
	Thousand short tons	Percent	Thousand short tons	Percent
Billets	149	10	187	11
Cakes	98	7	93	5
Cathodes	136	9	198	11
Ingots and ingot bars	154	10	238	13
Wire bars	926	63	1,050	59
Other forms	13	1	15	1
Total	1,476	100	1,781	100

Table 14.—Production, shipments, and stocks of copper sulfate

(Short tons)

Year	Production		Shipments	Stocks Dec. 31 [1]
	Quantity	Copper content		
1964	41,908	10,477	43,684	3,416
1965	47,340	11,835	45,640	5,048
1966	51,676	12,919	51,816	4,464
1967	40,128	10,032	40,644	3,516
1968	43,784	10,946	43,648	3,380

[1] Some small quantities are purchased and used by producing companies, so that the figures given do not balance exactly.

Table 15.—Byproduct sulfuric acid[1] (100-percent basis) produced in the United States

(Short tons)

Year	Copper plants [2]	Zinc plants [3]	Total
1964	330,273	924,100	1,254,373
1965	369,321	961,591	1,330,912
1966	469,728	983,118	1,452,846
1967	348,497	900,170	1,248,667
1968	483,108	989,973	1,473,081

[1] Includes acid from foreign materials.

[2] Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.

[3] Excludes acid made from native sulfur.

Table 16.—Secondary copper produced in the United States

(Short tons)

	1964	1965	1966	1967	1968
Copper recovered as unalloyed copper	366,197	462,811	509,084	423,054	433,041
Copper recovered in alloys [1]	726,824	790,439	825,165	736,853	785,299
Total secondary copper	1,093,021	1,253,250	1,334,249	1,159,907	1,218,340
Source:					
New scrap	619,500	739,814	799,389	677,248	697,568
Old scrap	473,521	513,436	534,860	482,659	520,772
Percentage equivalent of domestic mine output	88	93	93	122	101

[1] Includes copper in chemicals, as follows: 1964, 7,755; 1965, 6,129; 1966, 6,043; 1967, 4,965; and 1968, 4,757.

Table 17.—Copper recovered from scrap processed in the United States by kinds of scrap and form of recovery

(Short tons)

Kind of scrap	1967	1968	Form of recovery	1967	1968
New scrap:			As unalloyed copper:		
Copper-base	667,080	686,841	At primary plants	343,277	343,418
Aluminum-base	10,000	10,500	At other plants	79,777	89,628
Nickel-base	157	216			
Zinc-base	11	11	Total	423,054	433,041
Total	677,248	697,568	In brass and bronze	700,636	746,380
Old scrap:			In alloy iron and steel	2,805	3,527
Copper-base	476,471	515,530	In aluminum alloys	28,148	30,124
Aluminum-base	5,500	4,600	In other alloys	299	511
Nickel-base	623	600	In chemical compounds	4,965	4,757
Tin-base	15	17	Total	736,853	785,299
Zinc-base	50	25			
Total	482,659	520,772	Grand total	1,159,907	1,218,340
Grand total	1,159,907	1,218,340			

Table 18.—Copper recovered as refined copper, in alloys and in other forms from copper-base scrap processed in the United States

(Short tons)

Recovered by—	From new scrap		From old scrap		Total	
	1967	1968	1967	1968	1967	1968
Secondary smelters	60,474	65,683	250,514	262,806	310,988	328,489
Primary copper producers	216,385	185,752	126,892	157,666	343,277	343,418
Brass mills	372,744	414,891	39,830	36,214	412,574	451,105
Foundries and manufacturers	15,687	19,165	56,142	55,387	71,829	74,552
Chemical plants	1,790	1,349	3,093	3,457	4,883	4,806
Total	667,080	686,840	476,471	515,530	1,143,551	1,202,870

Table 19.—Production of secondary copper and copper-alloy products in the United States

(Short tons)

Item produced from scrap	1967	1968
UNALLOYED COPPER PRODUCTS		
Refined copper by primary producers	343,277	343,418
Refined copper by secondary smelters	63,337	73,161
Copper powder	14,994	15,164
Copper castings	1,446	1,298
Total	423,054	433,041
ALLOYED COPPER PRODUCTS		
Brass and bronze ingots:		
Tin bronze	19,137	16,810
Leaded tin bronze	17,964	15,312
Leaded red brass and semired brass	164,244	172,918
High-leaded tin bronze	34,588	34,846
Leaded yellow brass	18,626	24,586
Manganese bronze	16,246	16,547
Aluminum bronze	12,358	12,022
Nickel silver	5,251	4,217
Low brass	2,772	2,980
Silicon and conductor bronze	7,367	7,677
Copper-base hardeners and special alloys	13,339	13,382
Total	311,892	321,297
Brass-mill products	531,139	585,808
Brass and bronze castings	54,342	52,869
Brass powder	978	1,187
Copper in chemical products	4,965	4,757
Grand total	1,326,370	1,398,959

Table 20.—Composition of secondary copper-alloy production

(Short tons)

Year	Copper	Tin	Lead	Zinc	Nickel	Aluminum	Total
Brass and bronze production:[1]							
1967	244,974	14,583	20,098	31,280	885	72	311,892
1968	253,578	14,128	19,917	32,785	806	83	321,297
Secondary metal content of brass-mill products:							
1967	412,554	485	2,912	108,912	6,256	20	531,139
1968	452,618	543	3,555	126,671	2,392	29	585,808
Secondary metal content of brass and bronze castings:							
1967 [r]	43,192	2,009	5,638	3,409	49	45	54,342
1968	42,190	1,873	5,353	3,382	13	58	52,869

[r] Revised.
[1] About 94 percent from scrap and 6 percent from other than scrap.

Table 21.—Stocks and consumption of purchased copper scrap in the United States in 1968

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31
			New Scrap	Old Scrap	Total	
SECONDARY SMELTERS						
No. 1 wire and heavy copper	3,384	41,488	5,909	36,861	42,770	2,102
No. 2 wire, mixed heavy and light copper	3,467	85,889	15,908	71,708	87,616	1,740
Composition or red brass	5,352	89,644	18,925	71,873	90,798	4,198
Railroad-car boxes	208	1,820	---------	1,846	1,846	182
Yellow brass	7,227	64,266	9,182	56,589	65,771	5,722
Cartridge cases and brass	294	1,523	---------	1,595	1,595	222
Auto radiators (unsweated)	3,225	57,866	---------	57,666	57,666	3,425
Bronze	3,402	32,208	4,985	27,773	32,758	2,852
Nickel silver	966	5,089	715	4,678	5,393	662
Low brass	535	5,377	4,327	1,002	5,329	583
Aluminum bronze	240	476	301	257	558	158
Low-grade scrap and residues	6,813	60,809	48,690	9,474	58,164	9,458
Total	35,113	446,455	108,942	341,322	450,264	31,304
PRIMARY PRODUCERS						
No. 1 wire and heavy copper	3,880	116,354	62,079	55,486	117,565	2,669
No. 2 wire, mixed heavy and light copper	13,824	179,367	111,487	67,113	178,600	14,591
Refinery brass	398	6,167	5,494	1,033	6,527	38
Low-grade scrap and residues	15,707	207,898	70,889	139,745	210,634	12,971
Total	33,809	509,786	249,949	263,377	513,326	30,269
BRASS MILLS [1]						
No. 1 wire and heavy copper	14,499	130,084	107,075	23,009	130,084	7,568
No. 2 wire, mixed heavy and light copper	5,744	36,728	35,780	948	36,728	3,788
Yellow brass	27,013	259,009	259,009	---------	259,009	18,932
Cartridge cases and brass	8,272	110,238	92,192	18,046	110,238	5,894
Bronze	1,041	4,247	4,247	---------	4,247	730
Nickel silver	9,518	12,243	12,243	---------	12,243	7,054
Low brass	5,868	39,839	39,839	---------	39,839	3,452
Aluminum bronze	738	274	274	---------	274	222
Mixed alloy scrap	7,091	2,400	2,400	---------	2,400	3,510
Total [1]	79,784	595,062	553,059	42,003	595,062	51,150
FOUNDRIES, CHEMICAL PLANTS, AND OTHER MANUFACTURERS						
No. 1 wire and heavy copper	3,341	28,856	10,153	19,742	29,895	2,302
No. 2 wire, mixed heavy and light copper	1,891	14,412	4,721	9,941	14,662	1,641
Composition or red brass	639	4,681	1,674	2,966	4,640	680
Railroad-car boxes	1,833	24,445	---------	24,961	24,961	1,317
Yellow brass	996	6,785	3,355	3,679	7,034	747
Auto radiators (unsweated)	1,515	6,187	---------	6,728	6,728	974
Bronze	495	1,764	612	1,119	1,731	528
Nickel silver	5	70	21	50	71	4
Low brass	124	457	276	273	549	32
Aluminum bronze	251	682	508	197	705	228
Low-grade scrap and residues	2,787	11,934	3,782	8,164	11,946	2,775
Total	13,877	100,273	[2] 25,102	[2] 77,820	[2] 102,922	11,228
GRAND TOTAL						
No. 1 wire and heavy copper	25,104	316,782	185,216	135,098	320,314	14,641
No. 2 wire, mixed heavy and light copper	24,926	316,396	167,896	149,710	317,606	21,760
Composition or red brass	5,991	94,325	20,599	74,839	95,438	4,878
Railroad-car boxes	2,041	26,265	---------	26,807	26,807	1,499
Yellow brass	35,236	330,060	271,546	60,268	331,814	25,401
Cartridge cases and brass	8,566	111,761	92,192	19,641	111,833	6,116
Auto radiators (unsweated)	4,740	64,053	---------	64,394	64,394	4,399
Bronze	4,938	38,219	9,844	28,892	38,736	4,110
Nickel silver	10,489	17,402	12,979	4,728	17,707	7,720
Low brass	6,527	45,673	44,442	1,275	45,717	4,067
Aluminum bronze	1,229	1,432	1,083	454	1,537	608
Low-grade scrap and residues [3]	25,705	286,808	128,855	158,416	287,271	25,242
Mixed alloy scrap	7,091	2,400	2,400	---------	2,400	3,510
Total	162,583	1,651,576	937,052	724,522	1,661,574	123,951

---

[1] Brass-mill stocks include home scrap; purchased scrap consumption assumed equal to receipts, so lines in brass-mill and grand total sections do not balance.

[2] Of the totals shown, chemical plants reported the following: Unalloyed copper scrap, 609 tons of new and 2,417 old; copper-base alloy scrap 3,070 tons of new and 4,421 old.

[3] Includes stocks of refinery brass.

Table 22.—Consumption of copper and brass materials in the United States, by principal consuming groups

(Short tons)

Year and item	Primary producers	Brass mills	Wire mills	Foundries, chemical plants, and miscellaneous users	Secondary smelters	Total
1967:						
Copper scrap	479,940	539,180	-----------	99,684	422,680	1,541,484
Refined copper [1]	---------	650,374	1,240,236	36,004	8,978	1,935,592
Brass ingot	---------	4,361	-----------	[2] 319,536	---------	323,897
Slab zinc	---------	117,638	-----------	3,807	10,092	131,537
Miscellaneous	---------	---------	---------	150	6,728	6,878
1968:						
Copper scrap	513,326	595,062	-----------	102,922	450,264	1,661,574
Refined copper [1]	---------	652,450	1,189,274	32,222	6,354	1,880,300
Brass ingot	---------	5,213	-----------	[2] 321,292	---------	326,505
Slab zinc	---------	146,689	-----------	3,219	11,998	161,906
Miscellaneous	---------	---------	-----------	150	2,436	2,586

[1] Detailed information on consumption of refined copper will be found in table 27.
[2] Shipments to foundries by smelters plus decrease in stocks at foundries.

Table 23.—Foundry consumption of brass ingot, by types, in the United States

(Short tons)

	1964	1965	1966	1967	1968
Tin bronze	9,334	9,999	11,174	10,691	11,745
Leaded tin bronze	27,683	31,331	31,699	28,048	30,013
Leaded red brass	176,423	181,773	174,270	145,579	149,139
High-leaded tin bronze	21,014	22,930	23,595	20,928	20,021
Leaded yellow brass	12,938	19,767	17,349	15,866	25,428
Manganese bronze	9,264	9,816	10,331	10,254	10,274
Hardeners	4,071	4,349	4,035	4,096	3,822
Nickel silver	3,084	3,398	3,577	4,094	3,870
Aluminum bronze	7,820	8,122	8,361	7,953	10,202
Low brass	1,929	2,503	3,575	2,761	3,611
Total	273,560	293,988	287,966	250,270	268,125

Table 24.—Foundry consumption of brass ingot by types, refined copper, and copper scrap, in the United States in 1968, by geographic divisions and States

(Short tons)

Geographic division and State	Tin bronze	Leaded tin bronze	Leaded red brass	High-leaded tin bronze	Leaded yellow brass	Manganese bronze	Hardeners	Nickel silver	Aluminum bronze	Low brass	Total brass ingot	Refined copper consumed	Copper scrap consumed
New England:													
Connecticut	106	568	3,409	143	1,530	133	9	8	77	45	6,028	262	974
Massachusetts	508	1,190	4,894	355	45	222	62	242	71	254	7,843	391	841
Maine, New Hampshire, Rhode Island, Vermont	112	41	2,110	138	141	174	4	259	15	18	3,012	73	5
Total	726	1,799	10,413	636	1,716	529	75	509	163	317	16,883	726	1,820
Middle Atlantic:													
New Jersey	651	420	3,487	191	75	272	16	91	143	149	5,495	2,246	4,353
New York	758	1,305	13,998	803	709	1,122	45	151	1,161	157	20,209	1,126	5,668
Pennsylvania	1,216	6,299	16,031	2,102	1,343	1,164	1,416	449	1,798	683	32,501	4,627	13,662
Total	2,625	8,024	33,516	3,096	2,127	2,558	1,477	691	3,102	989	58,205	7,999	23,683
East North Central:													
Illinois	663	2,549	15,480	682	65	697	102	141	869	533	21,781	1,090	3,790
Indiana	31	443	13,955	672	317	371	711	312	107	130	17,049	950	6,723
Michigan	1,378	3,223	10,012	472	9,768	2,013	179	18	2,079	481	29,623	4,405	999
Ohio	1,783	7,028	14,472	8,865	450	1,375	221	73	710	201	35,178	4,749	8,946
Wisconsin	820	361	7,224	2,490	1,105	174	583	957	331	305	14,350	6,253	974
Total	4,675	13,604	61,143	13,181	11,705	4,630	1,796	1,501	4,096	1,650	117,981	17,447	21,432
West North Central:													
Iowa, Kansas, and Minnesota	466	185	5,051	206	103	337	116	58	299	186	6,983	368	1,549
Missouri, Nebraska, South Dakota	25	73	1,401	750	821	168			570		3,832	656	9,782
Total	491	258	6,452	956	924	505	116	58	869	186	10,815	1,024	11,331
South Atlantic:													
Delaware, District of Columbia, Florida, Georgia, Maryland	710	96	1,314	36	117	125	56	368	131	44	2,938	355	117
North Carolina, South Carolina, Virginia, West Virginia	257	4,083	3,367	317	401	198		-------	350		9,032	1,037	6,797
Total	967	4,179	4,681	353	518	323	56	368	481	44	11,970	1,392	6,914
East South Central: Alabama, Kentucky, Mississippi, Tennessee	358	694	10,756	1,018	6,235	661	60	212	28	147	20,169	277	9,697
West South Central: Arkansas, Louisiana, Oklahoma, Texas	1,181	504	8,762	429	899	421	7	320	995	141	13,659	561	2,185

Mountain: Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah	147	30	247	33	1	71	4	3	28	66	630	119	555
Pacific:													
California	557	895	12,914	109	1,194	440	231	208	220	54	16,822	498	11,971
Oregon and Washington	18	26	255	210	109	136	-------	-------	220	17	991	536	2,817
Total	575	921	13,169	319	1,303	576	231	208	440	71	17,813	1,034	14,788
Grand Total	11,745	30,013	149,139	20,021	25,428	10,274	3,822	3,870	10,202	3,611	268,125	30,579	92,405

Table 25.—Dealers' monthly average buying price for copper scrap and consumers' alloy-ingot prices at New York

(Cents per pound)

Grade	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
1967:													
No. 2 copper scrap	38.50	37.78	33.26	28.85	28.56	30.50	29.50	30.22	31.55	33.41	36.85	39.00	33.15
No. 1 composition scrap	32.00	31.94	30.14	27.55	27.41	28.95	28.50	29.02	29.50	29.59	30.45	29.50	29.95
No. 1 composition ingot	50.00	50.00	47.13	44.48	42.25	42.25	42.25	42.25	24.38	44.00	45.05	45.50	44.79
1968:													
No. 2 copper scrap	39.50	39.76	39.98	33.31	28.36	28.53	29.16	28.61	29.48	30.70	30.58	35.11	32.76
No. 1 composition scrap	29.50	29.76	30.12	25.86	24.00	24.88	25.50	25.50	26.03	27.76	27.64	30.52	27.25
No. 1 composition ingot	45.50	45.74	46.25	45.57	43.48	43.25	43.25	43.25	43.25	43.25	43.25	45.11	44.26

Source: Metal Statistics, 1969.

Table 26.—Primary refined copper supply and withdrawals on domestic account

(Short tons)

	1964	1965	1966	1967	1968
Production from domestic and foreign ores, etc.	1,656,395	1,711,793	1,710,984	1,132,982	1,437,386
Imports [1]	139,974	137,443	162,602	330,347	400,278
Stocks Jan. 1 [1]	52,000	37,000	35,000	43,000	27,000
Total available supply	1,848,369	1,886,236	1,908,586	1,506,329	1,864,664
Copper exports [1]	316,230	324,965	273,071	159,353	240,745
Stocks Dec. 31 [1]	37,000	35,000	43,000	27,000	48,000
Total	353,230	359,965	316,071	186,353	288,745
Apparent withdrawals on domestic account [2]	1,495,000	1,526,000	1,593,000	1,320,000	1,576,000

[1] May include some copper refined from scrap.

[2] Includes copper delivered by industry to the Government stockpiles.

Table 27.—Refined copper consumed by classes of consumers

(Short tons)

Year and class of consumer	Cathodes	Wire bars	Ingots and ingot bars	Cakes and slabs	Billets	Other	Total
1967:							
Wire mills	6,058	1,226,370	6,964	-------	-------	844	1,240,236
Brass mills	152,310	28,090	115,640	153,146	200,906	282	650,374
Chemical plants	---------	---------	1,386	-------	-------	1,014	2,400
Secondary smelters	4,908	---------	3,816	-------	-------	254	8,978
Foundries	1,873	93	13,096	(1)	[2] 171	893	16,126
Miscellaneous [3]	1,684	80	8,235	(1)	[2] 948	6,531	17,478
Total	166,833	1,254,633	149,137	153,146	202,025	9,818	1,935,592
1968:							
Wire mills	16,632	1,164,933	6,716	-------	-------	993	1,189,274
Brass mills	141,836	26,610	140,658	122,367	220,504	475	652,450
Chemical plants	---------	---------	520	-------	-------	1,123	1,643
Secondary smelters	3,583	---------	2,583	-------	-------	188	6,354
Foundries	501	65	12,278	10	143	1,096	14,093
Miscellaneous [3]	1,959	69	6,872	(1)	[2] 930	6,656	16,486
Total	164,511	1,191,677	169,627	122,377	221,577	10,531	1,880,300

[1] Included with "Billets" to avoid disclosing individual company confidential data.

[2] Includes "Cakes and slabs" to avoid disclosing individual company confidential data.

[3] Includes iron and steel plants, primary smelters producing alloys other than copper, consumers of copper powder and copper shot, and miscellaneous manufacturers.

Table 28.—Stocks of copper at primary smelting and refining plants in the United States, December 31

(Thousand short tons)

Year	Refined copper [1]	Blister and materials in process of refining [2]
1964	37	246
1965	35	246
1966	43	270
1967	27	220
1968	48	272

[1] May include some copper refined from scrap.

[2] Includes copper in transit from smelters in the United States to refineries therein.

Table 29.—Stocks of copper in fabricators' hands Dec. 31

(Short tons)

Year	Stocks of refined copper [1] (1)	Unfilled purchases of refined copper from producers (2)	Working stocks (3)	Unfilled sales to customers (4)	Excess stocks over orders booked [2] (5)
1964	429,989	107,244	381,677	225,366	−69,810
1965	462,519	129,349	395,396	288,681	−92,209
1966	558,599	134,732	407,345	361,559	−75,573
1967	479,572	98,716	415,765	269,474	−106,951
1968	514,553	128,919	420,186	273,469	−50,183

[1] Includes in-process metal and primary fabricated shapes. Also includes small quantities of refined copper held at refineries for fabricators' account.

[2] Columns (1) plus (2) minus (3) and minus (4) equal column (5).

Source: United States Copper Association.

Table 30.—Average weighted prices of copper deliveries [1]

(Cents per pound)

Year	Domestic copper [r]	Foreign copper
1964	32.6	33.0
1965	35.4	36.5
1966	36.6	50.5
1967	38.6	48.2
1968	42.2	51.4

[r] Revised.

[1] Covers copper produced in the United States and delivered here and abroad and copper produced abroad and delivered in the United States.

Source: Bureau of Mines reports from copper selling agencies, 1964–65, and Metals Week, 1966–68.

Table 31.—Average monthly quoted prices of electrolytic copper for domestic and export shipments, f.o.b. refineries, in the United States and for spot copper at London

(Cents per pound)

Month	1967				1968			
	Domestic delivered [1]	Domestic f.o.b. refinery [2]	Export f.o.b. refinery [2]	London spot [2] [3]	Domestic delivered [1]	Domestic f.o.b. refinery [2]	Export f.o.b. refinery [2]	London spot [2] [3]
January	37.81	37.872	49.839	56.17	38.12	(4)	54.923	64.08
February	38.12	38.103	50.201	55.18	38.12	(4)	61.570	78.22
March	38.12	38.076	46.692	49.70	38.68	(4)	61.058	77.06
April	38.12	38.170	42.996	43.81	42.12	42.189	50.131	56.92
May	38.12	38.118	43.233	46.88	42.12	42.070	45.996	49.47
June	38.12	38.083	43.802	45.87	42.12	42.096	48.705	51.16
July	38.12	38.295	43.388	45.00	42.12	41.714	45.650	47.58
August	38.12	39.090	44.966	47.09	42.12	41.701	45.043	47.71
September	38.12	(4)	45.450	47.77	42.12	41.719	47.491	50.06
October	38.12	(4)	47.431	51.29	42.12	41.711	46.586	48.74
November	38.12	(4)	54.692	62.20	42.12	41.709	46.629	49.56
December	38.12	(4)	53.615	60.16	42.12	41.712	49.745	53.35
Average	38.10	38.226	47.192	51.19	41.17	41.847	50.294	56.13

[1] American Metal Market.

[2] Metals Week.

[3] Based on average monthly rates of exchange by Federal Reserve Board.

[4] Suspended.

Table 32.—U.S. exports of copper by classes and countries

Year and country	Ore, concentrates, matte, (copper content)		Refined		Scrap	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	38,710	$22,928	159,353	$159,085	17,616	$14,236
1968:						
Africa	---------	---------	62	65	---------	---------
Argentina	---------	---------	273	273	---------	---------
Belgium-Luxembourg	8,167	4,702	7,336	7,518	1,278	900
Brazil	---------	---------	31,335	30,947	---------	---------
Canada	7,841	6,516	5,739	5,342	28,436	25,372
Chile	8,643	3,012	4	4	---------	---------
Colombia	---------	---------	1	1	---------	---------
France	---------	---------	30,403	29,487	20	20
Germany, West	7,677	7,328	29,501	28,755	1,131	1,002
India	---------	---------	15,216	14,991	---------	---------
Italy	52	39	38,992	37,459	163	135
Japan	13,949	10,718	18,823	18,389	1,385	1,038
Mexico	1,504	1,427	19	18	342	386
Netherlands	---------	---------	9,294	9,185	38	26
Oceania	---------	---------	49	52	---------	---------
Peru	4,569	2,675	---------	---------	---------	---------
Spain	7,594	6,459	794	790	554	521
Sweden	---------	---------	3,831	3,710	2	2
Switzerland	---------	---------	2,313	2,304	---------	---------
United Kingdom	1,317	470	37,773	37,425	120	101
Yugoslavia	3,677	3,556	1,302	1,457	583	501
Other	---------	---------	7,685	7,278	57	49
Total	64,990	46,902	240,745	235,450	34,109	30,053

Year and country	Blister		Pipes and tubing		Plates and sheets	
	Short tons[2]	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	20,982	$10,023	715	$1,314	247	$429
1968:						
Africa	---------	---------	31	69	1	3
Argentina	---------	---------	---------	---------	---------	---------
Belgium-Luxembourg	9,836	8,379	10	22	1	2
Brazil	---------	---------	3	6	---------	---------
Canada	2,221	669	201	372	42	83
Chile	---------	---------	---------	---------	(2)	1
Colombia	---------	---------	68	128	(2)	(2)
France	---------	---------	13	26	1	2
Germany, West	1,091	903	1	3	2	2
India	---------	---------	2	10	1	2
Italy	4	4	1	1	---------	---------
Japan	---------	---------	2	4	23	53
Mexico	---------	---------	5	12	25	40
Netherlands	---------	---------	3	7	1	4
Oceania	---------	---------	5	8	7	13
Peru	---------	---------	8	30	3	5
Spain	2,502	1,549	---------	---------	---------	---------
Sweden	---------	---------	1	2	---------	---------
Switzerland	---------	---------	2	5	1	2
United Kingdom	---------	---------	1	1	25	62
Yugoslavia	94	74	---------	---------	---------	---------
Other	1	1	241	513	11	18
Total	15,749	11,579	598	1,219	144	292

See footnotes at end of table.

Table 32.—U.S. exports of copper by classes and countries—Continued

Year and country	Wire and cable, bare		Wire and cable, insulated		Other copper manufactures[1]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967	4,971	$6,170	[r] 17,182	[r] $32,410	6,570	$7,472
1968:						
Africa	424	488	1,031	2,561	29	55
Argentina	---------	---------	52	176	16	26
Belgium-Luxembourg	6	7	24	169	27	65
Brazil	155	164	44	144	(2)	1
Canada	366	483	6,480	8,207	1,121	1,325
Chile	46	65	672	1,188	3	12
Colombia	6	12	120	286	525	546
France	27	36	401	758	174	241
Germany, West	18	23	465	1,663	170	292
India	(2)	2	86	174	14	26
Italy	5	8	146	817	15	50
Japan	40	52	300	1,197	54	72
Mexico	130	192	2,745	4,182	31	62
Netherlands	(2)	6	115	474	11	56
Oceania	4	6	203	773	18	48
Peru	21	27	110	274	8	15
Spain	9	12	105	670	2	3
Sweden	52	80	96	351	11	17
Switzerland	152	183	91	268	4	9
United Kingdom	21	43	192	1,049	36	123
Yugoslavia	---------	---------	19	61	599	583
Other	968	1,193	6,449	12,560	1,801	2,054
Total	2,450	3,082	19,946	38,002	4,669	5,681

[r] Revised.

[1] Does not include wire cloth: 1967; 1,394,086 square feet ($1,013,363); 1968: 975,618 square feet ($635,269).

[2] Less than ½ unit.

Table 33.—U.S. exports of copper by classes

Year	Ore, concentrates, and matte (copper content)		Blister		Refined copper and semimanufactures		Other copper manufactures[1]		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	1,413	$496	736	$431	319,314	$338,184	6,934	$7,804	328,397	$346,915
1967	38,710	22,928	20,982	10,023	[r] 200,084	[r] 213,644	[r] 6,570	7,472	[r] 266,346	[r] 254,067
1968	64,990	46,902	15,749	11,579	297,992	308,098	4,669	5,681	383,400	372,260

[r] Revised.

[1] Does not include wire cloth: 1966; 948,388 square feet ($503,074); 1967: 1,394,086 square feet ($1,013,363) 1968: 975,618 square feet ($635,269).

Table 34.—U.S. exports of copper-base alloy (including brass and bronze), by classes

Class	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Ingots	1,211	$1,253	772	$1,232
Scrap and waste	64,877	40,114	85,949	60,667
Bars, rods, and shapes	2,179	3,546	1,629	2,898
Plates, sheets, and strips	1,118	3,523	1,229	4,842
Pipes and tubing	2,092	3,986	1,520	2,966
Pipe fittings	2,846	8,578	2,757	8,818
Plumbers' brass goods	914	2,161	1,156	2,697
Welding rods and wire	910	2,466	1,079	2,430
Castings and forgings	401	881	564	838
Powder and flakes	1,036	1,571	1,154	1,807
Foil	634	1,609	725	2,279
Articles of copper and copperbase alloys, n.e.c	(1)	6,126	(1)	7,358
Total	78,213	75,809	98,584	98,322

[1] Quantity not reported.

Table 35.—U.S. exports of unfabricated copper-base alloy [1] ingots, bars, rods, shapes, plates, sheets, and strips

Year	Short tons	Value (thousands)
1966	4,868	$7,934
1967	4,503	8,322
1968	3,630	8,472

[1] Includes brass and bronze.

Table 36.—U.S. exports of copper sulfate

(Blue vitriol)

Year	Short tons	Value (thousands)
1966	3,563	$1,725
1967	979	776
1968	927	718

Table 37.—U.S. exports of copper scrap, by countries

Country	Unalloyed copper scrap				Copper alloy scrap			
	1967		1968		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	242	$217	1,278	$900	4,180	$2,152	10,887	$7,377
Canada	13,722	11,421	28,436	25,372	11,210	7,415	18,866	14,799
France	------	------	20	20	26	13	272	250
Germany, West	131	91	1,131	1,002	4,008	2,464	8,736	6,900
India	282	263	------	------	408	210	77	67
Italy	70	51	163	135	1,410	825	10,412	6,630
Japan	2,436	1,567	1,385	1,038	37,805	23,709	25,934	16,993
Mexico	7	6	342	386	39	19	143	146
Netherlands	------	------	38	26	330	187	643	510
Spain	541	460	554	521	884	499	3,372	2,450
Sweden	56	39	2	2	2,615	1,336	1,721	1,186
United Kingdom	18	7	120	101	91	64	3,018	2,002
Yugoslavia	50	42	583	501	1,126	844	598	467
Other	61	72	57	49	745	377	1,275	890
Total	17.616	14,236	34,109	30,053	64,877	40,114	85,949	60,667

Table 38.—U.S. imports and exports of brass and copper scrap

	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Exports:				
Copper-base alloy scrap (new and old)	64,877	$40,114	85,949	$60,667
Copper scrap	17,616	14,236	34,109	30,053
Imports for consumption:				
Brass scrap (gross weight	3,505	2,479	3,022	2,042
Copper scrap (copper content)	[r] 16,717	[r] 14,802	11,571	12,117

[r] Revised.

Table 39.—U.S. imports for consumption of copper scrap, by countries

Country	Unalloyed copper scrap (copper content)			
	Short tons	Value (thousands)	Short tons	Value (thousands)
	1967		1968	
Canada	[r] 14,771	[r] $13,482	9,385	$10,235
Dominican Republic	24	22	--------	--------
France	--------	--------	--------	--------
Germany, West	[r] 148	[r] 89	11	17
Japan	--------	--------	385	474
Mexico	1,388	909	899	697
Netherlands	2	1	1	3
Panama	71	58	--------	--------
Spain	52	27	--------	--------
United Kingdom	27	39	405	329
Other	234	175	485	362
Total	[r] 16,717	[r] 14,802	11,571	12,117

Country	Copper alloys scrap					
	Short tons gross weight	Short tons copper content	Value (thousands)	Short tons gross weight	Short tons copper content	Value (thousands)
	1967			1968		
Canada	2,025	1,414	$1,564	2,529	1,726	$1,733
Dominican Republic	208	175	133	--------	--------	--------
France	55	39	39	--------	--------	--------
Germany, West	--------	--------	--------	--------	--------	--------
Japan	24	17	16	3	1	2
Mexico	532	376	305	220	198	130
Netherlands	--------	--------	--------	32	25	21
Panama	259	218	184	--------	--------	--------
Spain	--------	--------	--------	--------	--------	--------
United Kingdom	142	101	97	22	19	22
Other	260	209	141	216	162	134
Total	3,505	2,549	2,479	3,022	2,131	2,042

[r] Revised.

Table 40.—U.S. imports[1] of copper (unmanufactured), by classes and countries

(Short tons, copper content, and thousand dollars)

Year and country	Ore, concentrates		Matte		Blister	
	Quantity	Value	Quantity	Value	Quantity	Value
1966	[r] 42,584	$37,165	371	$389	[r] 357,835	$297,896
1967:						
Australia	708	531	-----	-----	-----	-----
Belgium-Luxembourg	-----	-----	-----	-----	-----	-----
Canada	7,151	6,410	78	75	336	300
Chile	691	257	-----	-----	141,629	105,745
Germany, West	211	114	-----	-----	-----	-----
Mexico	145	68	-----	-----	2,937	2,636
Netherlands	-----	-----	-----	-----	-----	-----
Peru	6,614	5,390	1	34	84,329	75,731
Philippines	16,058	14,435	-----	-----	-----	-----
South Africa, Republic of	-----	-----	-----	-----	38,866	29,440
United Kingdom	-----	-----	-----	-----	-----	-----
Yugoslavia	-----	-----	-----	-----	-----	-----
Zambia	-----	-----	-----	-----	225	218
Other	1,313	1,118	1	1	1,000	994
Total	32,891	28,323	80	110	269,322	215,064
1968:						
Australia	942	742	-----	-----	-----	-----
Belgium-Luxembourg	-----	-----	-----	-----	-----	-----
Canada	6,711	5,776	503	487	155	145
Chile	-----	-----	-----	-----	136,320	108,256
Germany, West	-----	-----	-----	-----	-----	-----
Mexico	217	95	2	(2)	5,067	4,960
Netherlands	-----	-----	-----	-----	-----	-----
Peru	4,637	4,409	-----	-----	89,033	81,912
Philippines	14,543	15,258	1	1	-----	-----
South Africa, Republic of	-----	-----	-----	-----	38,243	30,696
United Kingdom	-----	-----	-----	-----	1	2
Yugoslavia	-----	-----	-----	-----	-----	-----
Zambia	-----	-----	-----	-----	-----	-----
Other	-----	-----	3	2	1,899	1,843
Total	27,050	26,280	509	490	270,718	227,814

Year and country	Refined		Scrap		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1966	[r] 164,328	$144,625	[r] 29,586	$31,819	[r] 594,704	$511,894
1967:						
Australia	2,247	2,232	-----	-----	2,955	2,763
Belgium-Luxembourg	20,678	19,290	-----	-----	20,678	19,290
Canada	140,602	122,521	[r] 14,617	[r] 13,333	[r] 162,784	[r] 142,639
Chile	30,791	30,298	-----	-----	173,111	136,300
Germany, West	33,269	33,399	[r] 21	[r] 25	[r] 33,501	[r] 33,538
Mexico	-----	-----	1,388	909	4,470	3,618
Netherlands	14,119	14,646	2	1	14,121	14,647
Peru	27,694	27,160	-----	-----	118,638	108,315
Philippines	-----	-----	-----	-----	16,058	14,435
South Africa, Republic of	3,220	3,223	-----	-----	42,086	32,663
United Kingdom	20,468	19,612	27	39	20,495	19,651
Yugoslavia	1,766	1,820	-----	-----	1,766	1,820
Zambia	9,577	9,354	-----	-----	9,802	9,572
Other	[r] 26,140	[r] 26,749	[r] 308	[r] 244	[r] 28,762	[r] 29,106
Total	[r] 330,571	[r] 310,304	[r] 16,363	[r] 14,551	[r] 649,227	[r] 568,352
1968:						
Australia	4,036	4,938	-----	-----	4,978	5,680
Belgium-Luxembourg	57,859	67,395	-----	-----	57,859	67,395
Canada	135,115	121,656	8,050	8,692	150,534	136,756
Chile	42,860	47,193	1,862	1,508	180,542	156,957
Germany, West	55,263	67,038	11	17	55,274	67,055
Mexico	1,121	1,592	899	697	7,306	7,344
Netherlands	3,699	4,290	1	3	3,700	4,293
Peru	18,525	19,617	-----	-----	112,195	105,938
Philippines	-----	-----	-----	-----	14,544	15,259
South Africa, Republic of	4,648	5,645	-----	-----	42,891	36,341
United Kingdom	22,572	29,098	405	329	22,978	29,429
Yugoslavia	9,740	11,986	-----	-----	9,740	11,986
Zambia	22,898	27,301	-----	-----	22,898	27,301
Other	21,942	27,508	692	706	24,536	30,059
Total	400,278	435,257	11,420	11,952	709,975	701,793

---

[r] Revised.

[1] Data are general imports, that is, they include copper imported for immediate consumption plus material entering the country under bond.

[2] Less than ½ unit.

Table 41.—U.S. imports[1] of copper (unmanufactured), by countries

Country	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	2,955	$2,763	4,978	$5,680
Belgium-Luxembourg	20,678	19,290	57,859	67,395
Canada	[r] 162,784	[r] 142,639	150,534	136,756
Chile	173,111	136,300	180,542	156,957
Germany, West	[r] 33,501	[r] 33,538	55,274	67,055
Mexico	4,470	3,613	7,306	7,344
Netherlands	14,121	14,647	3,700	4,293
Peru	118,638	108,315	112,195	105,938
Philippines	16,058	14,435	14,544	15,259
South Africa, Republic of	42,086	32,663	42,891	36,341
United Kingdom	20,495	19,651	22,978	29,429
Yugoslavia	1,766	1,820	9,740	11,986
Zambia	9,802	9,572	22,898	27,301
Other	[r] 28,762	[r] 29,106	24,536	30,059
Total	[r] 649,227	[r] 568,352	709,975	701,793

[r] Revised.

[1] Data are general imports, that is, they include copper imported from immediate consumption plus material entering the country under bond.

Table 42.—U.S. imports for consumption of old brass and clippings from brass or Dutch metal[1]

Year	Short tons		Value (thousands)
	Gross weight	Copper content	
1966	7,360	5,056	$5,846
1967	3,505	2,549	2,479
1968	3,022	2,131	2,042

[1] For remanufacture.

Table 43.—U.S. imports for consumption of copper (copper content) by classes

Year	Ore and concentrates		Matte		Blister		Refined		Scrap		Total value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1966	6,843	$4,118	117	$85	337,955	$272,996	77,783	$63,654	23,908	$24,662	$365,515
1967	35,673	28,820	2	35	[r] 270,728	[r] 217,473	[r] 332,290	[r] 311,415	[r] 16,717	[r] 14,802	[r] 572,545
1968	71,884	66,291	8	4	274,180	224,013	403,630	438,608	11,571	12,117	741,033

[r] Revised.

Table 44.—World mine production of copper, by countries [1] [2]

(Short tons)

Country	1964	1965	1966	1967	1968 p
North America:					
Canada [3]	486,897	507,874	507,874	602,645	608,188
Cuba	6,434	• 6,600	• 6,600	• 7,000	• 7,000
Haiti	5,544	4,365	3,064	2,590	1,761
Mexico	57,399	60,900	62,295	61,725	67,343
Nicaragua	10,185	11,229	10,863	10,291	12,898
United States [3]	1,246,780	1,351,734	1,429,152	954,064	1,204,621
South America:					
Argentina	380	571	r 371	552	• 450
Bolivia [4]	5,218	5,221	6,423	6,710	7,680
Brazil •	2,200	r 2,506	r 2,365	2,369	NA
Chile	698,140	667,898	r 731,243	731,789	729,348
Ecuador	188	142	246	457	456
Peru	[3] 194,497	[3] 198,786	194,441	199,668	235,356
Europe:					
Albania •	2,800	r 4,620	r 5,500	• 6,600	6,612
Austria [3]	1,725	1,678	2,043	2,156	2,327
Bulgaria	22,487	32,959	• r 33,000	• 34,200	35,264
Finland	r 35,878	r 33,236	r 29,448	32,227	• 32,780
France	294	312	478	446	440
Germany:					
East	r 24,354	r 22,590	r 20,827	22,000	22,000
West	1,759	1,184	1,386	1,300	1,472
Ireland	-----------	-----------	r 1,389	3,887	7,162
Italy	r 843	783	1,269	1,851	2,540
Norway [5]	16,505	16,278	16,331	15,927	18,563
Poland •	16,000	16,600	17,700	18,132	18,700
Portugal [5]	4,812	4,799	4,117	4,037	• 3,960
Spain [5]	10,882	9,674	r 9,664	• 10,120	• 10,100
Sweden	17,846	17,402	r 16,836	• 16,530	• 18,700
U.S.S.R. • [6]	715,000	770,000	825,000	880,000	880,000
Yugoslavia	69,648	68,951	68,588	69,593	70,400
Africa:					
Algeria	1,204	1,130	1,184	1,175	1,155
Congo (Kinshasa)	304,943	318,132	347,960	351,511	353,311
Morocco	1,927	1,998	2,956	2,784	3,357
Rhodesia, Southern	18,341	19,800	• r 16,610	• 19,140	• 20,000
South Africa, Republic of	65,579	r 66,566	r 137,377	140,593	141,351
South-West Africa, Territory of	38,698	43,456	42,906	• 41,800	• 40,700
Uganda	r 19,862	r 20,731	r 20,768	19,181	20,554
Zambia	697,047	766,924	687,226	729,789	732,910
Asia:					
Burma •	140	150	110	103	44
China, mainland •	99,000	99,000	99,000	88,000	99,000
Cyprus •	r 14,300	r 22,535	r 19,567	17,089	18,773
India	11,553	11,153	11,354	9,462	10,000
Iran	9,736	10,554	12,122	13,224	• 13,200
Israel •	r 8,030	r 8,250	r 8,580	7,812	8,470
Japan	117,037	118,021	123,105	130,878	131,934
Korea:					
North •	11,000	11,000	13,000	13,200	13,200
South •	937	1,260	1,274	1,542	1,321
Philippines	66,643	69,159	81,304	94,161	125,524
Taiwan	1,916	• r 2,090	• r 2,754	• 2,530	2,530
Turkey	38,030	37,038	40,124	34,707	31,761
Oceania:					
Australia	r 116,503	101,235	r 122,647	101,055	117,680
Fiji (exports)	-----------	-----------	-----------	-----------	• 924
Total [7]	r 5,297,121	r 5,549,074	r 5,800,341	5,518,602	5,893,620

• Estimate. p Preliminary. r Revised. NA Not available.

[1] Figures shown represent copper content (recoverable where indicated) of ores mined when available data are adequate. If data for ores are incomplete or lacking, the figures include the nonduplicative copper content of concentrates, matte, metal, or other copper-bearing products, measured at the least stage of processing represented.

[2] Czechoslovakia, Hungary, Kenya, and Malasia also produce copper, but production data are not available

[3] Recoverable.

[4] COMIBOL production plus exports by small and medium mines.

[5] Includes copper content of cupriferous pyrites.

[6] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[7] Total is of listed figures only.

Table 45.—World smelter production of copper, by countries [1]

(Thousand short tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada	407,942	434,133	433,921	499,879	524,807
Mexico	55,383	59,534	60,889	60,012	65,884
United States [2]	1,338,433	1,434,050	1,466,436	862,340	1,266,478
South America:					
Brazil [e] [3]	[r] 3,630	4,015	3,850	3,850	3,850
Chile	[r] 645,781	[r] 633,395	[r] 696,223	695,437	691,465
Peru	167,625	174,851	166,533	172,695	205,109
Europe: [4]					
Albania	2,429	[r] 4,576	4,620	4,620	4,620
Austria [3] [5]	16,140	17,864	18,767	19,223	19,957
Bulgaria	23,261	27,831	[r] 29,928	[e] 29,700	[e] 30,800
Finland [3]	36,571	33,645	35,177	37,659	39,556
Germany:					
East [e] [3]	[r] 44,000	[r] 44,000	[r] 44,000	44,000	44,000
West [3]	370,728	393,946	413,773	421,439	[e] 462,000
Norway	19,301	22,140	21,960	22,373	25,875
Poland	40,394	41,226	43,924	46,200	48,047
Spain	23,595	34,197	[r] 26,494	31,961	50,300
Sweden	50,323	[r] 55,704	56,438	52,565	51,353
U.S.S.R. (Primary) [e]	715,000	770,000	825,000	880,000	880,000
Yugoslavia [3]	57,007	62,742	78,640	84,531	[e] 84,700
Africa:					
Congo (Kinshasa)	304,943	318,132	347,960	351,512	353,332
Rhodesia, Southern	16,798	[e] 19,000	[e] 18,900	NA	NA
South Africa, Republic of	60,090	60,022	[r] 137,376	140,544	141,312
South-West Africa, Territory of	31,428	32,745	36,412	[e] 37,400	[e] 32,000
Uganda	20,128	18,895	17,745	15,897	17,188
Zambia	708,616	754,966	421,738	679,762	732,279
Asia:					
China (mainland) [e]	110,000	110,000	110,000	90,000	110,000
India	[r] 10,441	10,318	[r] 10,317	9,812	10,233
Japan	376,658	403,095	446,267	517,986	604,343
Korea:					
North [e]	11,000	13,000	13,000	13,000	13,000
South	3,097	2,973	4,268	4,075	5,021
Taiwan	2,080	2,412	2,658	3,301	[e] 3,301
Turkey	28,639	28,991	29,340	27,980	26,029
Oceania: Australia	90,259	82,224	101,345	79,303	102,492
Total [6]	[r] 5,791,720	[r] 6,104,622	[r] 6,123,899	5,939,056	6,649,331

---

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Data include blister copper, refined copper of nonblister origin, and refined copper derived from unreported quantities of domestically smelted blister copper. Data are presumed to represent primary copper unless otherwise indicated.

[2] Smelter output from domestic and foreign ores, exclusive of scrap. Production from domestic ores only, exclusive of scrap, was as follows: 1964, 1,301,107; 1965, 1,402,798; 1966, 1,429,854; 1967, 941,343; and 1968, 1,233,951.

[3] Includes secondary copper.

[4] Belgium reports a large output of refined copper which is believed to be produced principally from crude copper from Congo (Kinshasa); it is not shown here, as that would duplicate output reported under latter country.

[5] May include some scrap in raw materials; excludes fire refined copper.

[6] Totals are of listed figures only.

Table 46.—Chile: Exports of copper, by principal types

(Short tons, copper content)

Destination	1967 [r]				1968			
	Refined				Refined			
	Electrolytic	Fire refined	Blister	Total	Electrolytic	Fire refined	Blister	Total
Argentina	15,585	3,963	-------	19,548	17,636	5,088	-------	22,724
Australia	-------	-------	-------	-------	-------	336	-------	336
Austria	928	-------	-------	928	897	-------	-------	897
Belgium	-------	627	34,397	35,024	-------	1,400	9,641	11,041
Brazil	6,316	1,895	-------	8,211	7,497	1,444	-------	8,941
Colombia	-------	22	-------	22	-------	712	-------	712
Denmark	1,867	-------	-------	1,867	1,092	-------	-------	1,092
Finland	2,873	-------	-------	2,873	3,527	-------	-------	3,527
France	30,235	13,963	-------	44,198	23,645	13,928	-------	37,573
Germany, West	77,475	12,942	50,585	141,002	87,283	14,536	20,494	122,313
Italy	38,744	20,422	1,504	60,670	35,400	18,059	1,315	54,774
Japan	18,772	5,589	-------	24,361	25,467	-------	19,912	45,379
Netherlands	399	-------	-------	399	1,216	-------	-------	1,216
Norway	3,316	-------	-------	3,316	3,527	-------	-------	3,527
Spain	6,034	1,680	-------	7,714	6,823	1,344	675	8,842
Sweden	16,512	7,056	9,967	33,535	19,633	9,801	8,542	37,976
Switzerland	2,339	1,809	-------	4,148	1,719	1,702	-------	3,421
United Kingdom	54,505	20,310	37,029	111,844	63,551	19,224	39,035	121,810
United States	28,556	3,360	131,810	163,726	28,202	1,560	147,759	177,521
Other	44	153	-------	197	-------	205	-------	205
Total	304,500	93,791	265,292	663,583	327,115	89,339	247,373	663,827

[p] Preliminary. [r] Revised.
Source: Corporatión del Cobre de Chile.

Table 47.—Peru: Copper production

(Short tons)

Year	Blister	Refined	Other	Total
1964	125,935	41,679	26,883	194,497
1965	130,250	44,600	23,936	198,786
1966	124,674	41,859	27,908	194,441
1967	134,152	38,592	26,924	199,668
1968	162,682	42,427	30,147	235,256

Table 48.—Canada: Copper production (all sources) by Provinces [1]

(Short tons)

Province	1967	1968 [p]
British Columbia	86,319	82,425
Manitoba	29,560	29,776
New Brunswick	5,786	8,060
Newfoundland	21,965	21,860
Northwest Territories	566	1,049
Nova Scotia	28	91
Ontario	276,146	288,484
Quebec	166,385	156,113
Saskatchewan	22,975	22,735
Yukon Territories	3,584	5,983
Total	613,314	616,576

[p] Preliminary.

[1] Blister copper plus recoverable copper in matte and concentrate exported.

Source: Dominion Bureau of Statistics, Department of Trade and Commerce, Dominion of Canada, Canada's Mineral Production, Preliminary Estimate, 1968.

Table 49.—United Kingdom: Exports and reexport of copper, by countries

(Short tons)

Destination	1967	1968
Argentina	755	166
Belgium	1,728	1,822
Brazil	382	545
China, mainland	11,977	2,817
Czechoslovakia	1,289	1,150
Denmark	137	4
France	1,060	3,520
Germany, West	[r] 17,164	10,811
India	[r] 2,367	1,202
Italy	2,107	1,400
Netherlands	[r] 9,060	10,506
Norway	122	45
Pakistan	[r] 647	834
Poland	5,244	2,742
Spain	3,064	3,151
Sweden	549	926
United Arab Republic	------	1,892
United States	[r] 10,198	17,222
Other	[r] 892	2,241
Total	[r] 68,742	62,496

[r] Revised.

Source: World Metal Statistics, Published by World Bureau of Metal Statistics.

Table 50.—United Kingdom: Imports of copper by countries

(Short tons)

Country	1967			1968		
	Blister	Electrolytic	Fire refined	Blister	Electrolytic	Fire refined
Australia	--------	2,547	--------	--------	2,857	--------
Belgium	--------	6,756	--------	--------	9,449	--------
Canada	--------	[r] 97,002	--------	--------	98,805	--------
Chile	34,100	59,469	20,897	39,648	58,909	17,860
Congo (Kinshasa)	--------	4,817	--------	--------	5,542	--------
Germany, West	--------	[r] 10,195	--------	--------	11,517	--------
Netherlands	--------	6,003	--------	--------	3,142	--------
Norway	--------	[r] 1,040	--------	--------	2,117	--------
Peru	--------	28	--------	--------	224	--------
South Africa, Republic of	146	199	7,801	196	7,508	10,836
Spain	--------	3,912	--------	--------	1,188	--------
Sweden	--------	15,776	--------	--------	8,870	--------
United States	--------	[r] 30,313	506	--------	26,046	1,538
U.S.S.R	--------	4,205	--------	--------	2,900	--------
Zambia	[1] 542	[r] 189,918	--------	[1] 4,210	189,072	--------
Other	--------	1,075	57	78	2,831	276
Total	34,788	[r] 433,255	29,261	44,132	430,977	30,510

[r] Revised.

[1] Includes fire refinable anodes.

Source: World Metal Statistics, Published by World Bureau of Metal Statistics.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/66

Diatomite

By J. M. West[1]

Domestic production and sales of diatomite in 1968 declined 10 percent in quantity from that of 1967 but remained almost unchanged in total value. The decline in quantity, largely the result of a drop in sales of pozzolan and coating agent products, was offset by an increase of 10 percent in the average value of overall products marketed during the year. The United States produced about one-third of the world's diatomite needs and supplied probably over one-half of the world's filtration grade material in 1968.

DOMESTIC PRODUCTION

The tonnage of diatomite produced was lower in 1968, with the greatest decline in California, the leading producing State. Nevada and Washington were also significant sources while Oregon and Arizona produced only minor quantities. During the year, 11 companies with 13 plants processed diatomite. Johns-Manville Corp., with facilities at Lompoc, Calif. remained the dominant producer and expanded its plant capacity with the aim of processing 800 to 1,000 tons per day in 1969. Large quantities of waste material were mined, as in the past, to reach the specific beds of diatomite desired. Eagle-Picher Industries, Inc., largest Nevada producer, installed a second rotary furnace at its plant near Lovelock expecting to double capacity. Airox Co., a producer chiefly of pozzolan from diatomite, sold its facilities in Santa Barbara County, Calif., to Pozzolan Products Inc. in the latter part of the year.

CONSUMPTION AND USES

Filtration products grew in both absolute tonnage and proportion of total diatomite consumed in 1968; filler use also expanded though somewhat less. The quantity and proportion of diatomite used for insulation remained about constant. In the miscellaneous category, the main declines came in pozzolans and coating agents, possibly because of substitutions. Other uses included absorbents, carriers for insecticides and catalysts, lightweight aggregates, and soil conditioner.

---

[1] Physical scientist, San Francisco office of Mineral Resources, Bureau of Mines.

Table 1.—Diatomite sold or used by producers in the United States, 3-year totals[1]

	1954–56	1957–59	1960–62	1963–65	1966–68
Domestic production (sales) short tons	1,105,279	1,349,340	1,446,625	1,740,833	1,881,877
Average value per ton	$39.21	$45.73	$50.08	$50.40	$54.18

[1] Annual figures are company confidential.

Table 2.—Domestic consumption of diatomite, by principal use, in percent of total consumption

Use	1964	1965	1966	1967	1968
Filtration	47	44	46	48	55
Fillers	24	20	20	18	21
Insulation	4	6	5	4	4
Miscellaneous	25	30	29	30	20

PRICES

Prices of filtration and filler grades rose substantially in 1968 because of rising costs of labor, materials, and distribution, and at yearend further price increases were being discussed.

Table 3.—Average annual value per ton of diatomite, by uses

Use	1967	1968
Filtration	$61.15	$67.74
Insulation	54.31	44.50
Abrasives	131.78	128.70
Fillers	53.18	57.20
Miscellaneous	87.93	85.84
Weighted average	52.54	57.98

FOREIGN TRADE

Significant tonnages of diatomite products continued to be exported to many parts of the world. Imports were of little consequence and totaled only 132 short tons from Canada, Uganda, and Mexico.

Table 4.—U.S. exports of diatomite

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1966	144	$11,500
1967	148	11,324
1968	168	12,008

WORLD REVIEW

There was little international news on diatomite during the year. World production continued to rise in keeping with established trends. Major world producers in order of importance were the United States, U.S.S.R., France, Italy, and West Germany. The new jointly owned Johns-Manville Corp.—Government of Iceland diatomite mine and mill, under construction at Lake Myvatin, was due to begin supplying products chiefly for export to European markets in 1968–69. Prospects were considered good enough that doubling capacity to 24,000 tons per year was already under consideration.

Table 5.—World production of diatomite, by countries[1]

(Short tons)

Country	1964	1965	1966	1967	1968 ᵖ
North America:					
Canada	1,148	82	70	NA	NA
Costa Rica ᵉ	3,968	3,307	3,307	11,023	11,023
Mexico	2,260	987	9,327	7,921	10,961
United States [2]	580,275	580,275	ʳ 627,292	627,292	627,292
South America:					
Argentina	8,567	6,774	ʳ 12,063	8,979	NA
Colombia	255	220	-----------	NA	NA
Peru	2,858	2,724	1,742	4,118	NA
Europe:					
Austria	4,224	4,447	4,138	4,031	3,284
Denmark:					
Diatomite ᵉ	20,393	13,779	11,023	11,023	11,023
Moler ᵉ [3]	210,761	234,461	223,989	220,462	220,462
Finland	2,392	1,047	1,328	1,785	2,182
France [4]	146,699	166,046	ʳ 155,710	176,370	NA
Germany, West (marketable) ᵉ [4]	116,845	126,766	98,106	98,106	117,947
Iceland	-----------	-----------	-----------	-----------	2,750
Italy	76,445	ʳ 69,739	ʳ 69,131	66,088	ᵉ 66,139
Portugal [4]	2,207	2,896	ʳ 3,845	4,308	3,307
Spain [4]	ᵉ 12,507	13,131	ᵉ 17,637	ᵉ 17,637	ᵉ 17,637
Sweden [5]	955	1,342	3,617	2,205	3,307
U.S.S.R. ᵉ	352,739	363,762	385,808	396,832	396,832
United Kingdom	15,363	16,888	ʳ 16,460	ᵉ 16,424	NA
Africa:					
Algeria	22,163	18,092	ᵉ ʳ 17,637	20,128	19,842
Kenya	3,868	2,445	1,953	2,079	2,265
Rhodesia, Southern [4]	347	ᵉ 529	ᵉ 529	NA	NA
South Africa, Republic of	546	1,076	240	645	688
Asia: Korea, South	ʳ 620	638	ʳ 308	2,467	2,441
Oceania:					
Australia	9,780	7,793	ʳ 8,006	9,818	ᵉ 2,205
New Zealand	1,881	1,937	5,219	1,577	NA
Total [6]	ʳ 1,599,561	ʳ 1,641,183	ʳ 1,678,475	1,710,813	1,521,587

ᵉ Estimate. ᵖ Preliminary. ʳ Revised. NA Not available.

[1] Diatomaceous earth is produced in Brazil, Bulgaria, Hungary, Japan, Mozambique, Rumania, United Arab Republic, and Yugoslavia but outputs are insignificant or not available.

[2] Average annual production from the appropriate 3-year totals, 1963–65 and 1966–68.

[3] Moler earth used as a raw material in making refractory bricks plus exports in bulk form.

[4] Includes tripoli.

[5] Includes calcined.

[6] Totals are of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/166

Feldspar, Nepheline Syenite, and Aplite

By J. Robert Wells[1]

FELDSPAR

The quantity of feldspar sold or used by producers in the United States in 1968 was the largest in the history of the industry, exceeding by a substantial margin all previous figures for both tonnage and total value. Utilization of feldspar for ceramics and miscellaneous lesser applications remained active throughout the year, but the glass industry continued to account for the major share of the demand for feldspar and related materials. Domestic production of flat glass for automobiles and buildings was 10 to 15 percent beyond the 1967 mark, and commercial production of glass-fiber reinforced automobile tires provided a minor but assuredly multiplying increment to the requirement for glass-grade feldspar.

Glass formulations containing substantial proportions of feldspar (sometimes aplite) are especially favorable for machine manufacture of glass containers, and production of nonreturnable beverage bottles continued at a fast pace. It is indicative that 35 percent more feldspar entered into glassmaking in 1968 than in 1960, while the output of throwaway soft-drink bottles rose from less than 2 million gross in 1960 to an estimated 37 million gross in 1968. With an equal or greater number of nonreturnable beer bottles also being produced in 1968, there was growing concern over the litter problem of the jettisoned containers that led to serious discussion of some type of regulatory legislation.

Price increases reported for feldspathic materials in 1968 appeared to be more a reflection of current inflationary tendencies than of any tightness of supply.

DOMESTIC PRODUCTION

Crude Feldspar.—North Carolina, California, Connecticut, and Georgia, in that order, jointly contributed more than 83 percent of the whole domestic supply of crude feldspar in 1968. Nine other States, including for the first time New Mexico, also produced crude feldspar. Among the more than 50 domestic firms that mined crude feldspar in 1968, the combined output of the four leaders amounted to 74 percent of the National total, and that of the four next in order to about 17 percent. One company in Connecticut, formerly a substantial supplier, ceased operations at the start of the year. Over 64 percent of the U.S. production in 1968 was classified as flotation concentrate, up from 61 percent in 1967, while the proportion of hand-cobbed material shrank from 16 percent to 12 percent, the third consecutive annual decrease.

Ground Feldspar.—In 1968 there were 17 mills engaged in grinding feldspar in nine States, among which North Carolina, California, and Connecticut led in tonnage—North Carolina, Connecticut, and Georgia in total value of product.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Salient feldspar statistics

	1964	1965	1966	1967	1968
United States:					
Crude:					
Sold or used by producers long tons	587,194	624,598	655,452	615,397	667,679
Value thousands	$5,389	$6,263	$7,020	$7,086	$8,265
Average value per long ton	$9.18	$10.03	$10.71	$11.51	$12.38
Imports for consumption long tons	10	16	---------	280	---------
Value thousands	$1	$2	---------	$8	---------
Average value per long ton	$84.00	$95.00	---------	$28.04	---------
Consumption, apparent [1] long tons	587,204	624,614	655,452	615,677	667,679
Ground:					
Sold by merchant mills short tons	646,974	664,138	703,587	663,220	730,737
Value thousands	$7,644	$7,757	$8,944	$8,843	$9,242
Average value per short ton	$11.82	$11.68	$12.71	$13.33	$12.65
Imports for consumption long tons	3,170	3,439	3,243	2,783	3,377
Value thousands	$85	$92	$86	$72	$91
Average value per long ton	$26.95	$26.87	$26.52	$26.00	$26.86
World: Production thousand long tons	1,862	1,974	2,116	1,974	NA

[1] Measured by quantity sold or used by producers plus imports.

Table 2.—Crude feldspar sold or used by producers in the United States

Year	Derivation of feldspar [1]							
	Hand-cobbed		Flotation concentrate		Feldspar-silica mixtures [2]		Total	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1964	88,046	$804	380,787	$3,367	118,361	$1,218	587,194	$5,389
1965	126,811	1,072	369,585	3,974	128,202	1,217	624,598	6,263
1966	116,936	997	407,450	4,803	131,066	1,220	655,452	7,020
1967	[r] 97,409	[r] 848	[r] 385,005	[r] 4,900	[r] 132,983	1,338	615,397	7,086
1968	78,401	670	427,770	5,845	161,508	1,750	667,679	8,265

[r] Revised.
[1] Partly estimated.
[2] Feldspar content.

Table 3.—Ground feldspar sold by merchant mills[1] in the United States

	Mills	Domestic feldspar	
		Short tons	Value (thousands)
1964	20	646,974	$7,644
1965	20	664,138	7,757
1966	19	703,587	8,944
1967	19	663,220	8,843
1968	17	730,737	9,242

[1] Excludes potters and others who grind for consumption in their own plants.

Table 4.—Ground feldspar sold by merchant mills in the United States, by derivation[1] and uses

(Short tons)

Year	Glass	Pottery	Enamel	Other	Total	Glass	Pottery	Enamel	Other	Total
	Hand-cobbed					Flotation concentrate				
1964	W	51,703	W	45,952	97,655	255,907	W	W	163,548	419,455
1965	W	32,535	W	75,055	107,590	256,000	W	W	162,014	418,014
1966	W	54,678	W	61,090	115,768	281,595	W	W	203,819	485,414
1967	W	38,539	W	61,473	100,012	282,861	W	------	178,754	461,615
1968	W	67,752	W	61,951	129,703	284,487	W	------	180,960	465,447
	Feldspar-silica mixtures[2]					Grand total[3]				
1964	W	W	------	129,864	129,864	349,715	189,853	21,925	85,481	646,974
1965	W	W	------	138,534	138,534	368,120	174,537	42,268	79,213	664,138
1966	W	W	------	102,405	102,405	378,464	207,209	36,151	81,763	703,587
1967	W	W	------	101,593	101,593	379,660	208,626	15,304	59,630	663,220
1968	W	W	------	135,587	135,587	396,758	240,251	20,759	72,969	730,737

W Withheld to avoid disclosing individual company confidential data; included with "Other."

[1] Partly estimated.

[2] Feldspar content.

[3] "Other" includes soaps, abrasives, and other ceramic and miscellaneous uses.

CONSUMPTION AND USES

Crude Feldspar.—In 1968, as usual, nearly all the commercial feldspar was processed to some degree before being sold or used in industry, although a small number of users continued their accustomed practice of purchasing minor quantities of the crude mineral for preparation in their own mills and according to their own established standards.

Ground Feldspar.—The total quantity of ground feldspar sold in 1968 by U.S. merchant mills was distributed among the principal consuming outlets in the following proportions: 54 percent glass, 33 percent pottery, and 3 percent enamel, not significantly different from the respectively comparable figures of 57 percent, 31 percent, and 2 percent for 1967.

Table 5.—Ground feldspar shipped from merchant mills in the United States

(Short tons)

Destination	1964	1965	1966	1967	1968
California	120,804	111,174	109,126	100,235	W
Illinois	73,967	66,160	63,038	59,837	64,628
Indiana	20,998	W	W	W	25,897
Kentucky	W	3,775	7,052	15,433	10,180
Massachusetts	4,407	4,787	3,980	3,539	3,896
Mississippi	---------	---------	---------	7,845	8,685
New Jersey	58,089	57,096	71,057	W	W
New York	22,117	26,037	W	W	20,311
Ohio	80,119	87,873	70,294	72,701	87,202
Pennsylvania	37,805	30,281	30,628	26,188	27,338
Tennessee	---------	33,851	36,002	32,998	26,898
Texas	W	W	26,183	23,269	24,449
West Virginia	26,638	W	W	W	34,720
Other destinations[1]	202,030	243,104	286,227	321,175	396,538
Total	646,974	664,138	703,587	663,220	730,737

W Withheld to avoid disclosing individual company confidential data; included with "Other destinations."

[1] Includes Arkansas (1964–65, 1967–68); Colorado (1964–65, 1967–68); Connecticut (1964–65); Georgia (1964–65); Idaho (1965); Kansas (1966); Louisiana (1967–68); Maryland (1968); Michigan (1967–68); Minnesota (1967–68); Missouri (1967–68); Oklahoma (1964, 1967–68); Rhode Island (1964, 1967–68); Tennessee (1964); South Carolina (1964–65); Vermont (1964–65); Virginia (1966); Washington (1964, 1967–68); Wisconsin (1967–68); shipments that cannot be separated by States; and items indicated by symbol W. Also includes exports to Africa (1965, 1967); Canada (1967–68); Mexico (1964, 1966–68); Panama (1964, 1966–67); Philippines (1964, 1966–68); Venezuela (1968); and small quantities to other countries.

PRICES

Average per-ton values reported to the Bureau of Mines for crude feldspar in 1968 were substantially higher than in 1967, the fourth successive annual increase. Feldspar prices, per ton, listed in the Materials Cost Index of the January 1969 issue of Ceramic Industry Magazine were as follows: Glass grade, \$10 to \$20; 140 mesh, \$18.50 to \$22.50; and 200 mesh, \$18.50 to \$23.50. The prices for the first category were somewhat higher than the corresponding figures that appeared in January 1968, but quotations for the other two classifications were unchanged. Prices published in the Markets section of Engineering and Mining Journal for December 1968 were in an essentially similar range.

FOREIGN TRADE

In 1968, U.S. imports of ground feldspar for consumption were close in both volume and value to the average established in the current decade, but there were no imports of crude feldspar or of crude or ground Cornwall stone. According to data released by the Department of Commerce, 1968 exports in the composite classification of feldspar, leucite, nepheline, and nepheline syenite totaled to about 13,000 long tons, more than double the quantity in the preceding year and nearly 80 percent greater in total value.

WORLD REVIEW

Finland.—Lojo Kalkverk, the first commercial producer of flotation feldspar in Europe, furnished 12,000 tons of that product for export in 1966 and 35,000 tons in 1967, with the comparable final figure for 1968 expected to reach 50,000 tons. It was announced that the firm's Kimito flotation plant will be expanded to bring its production capacity to 100,000 tons of feldspar concentrate per year.

Italy.—A new plant, completed near Giustino in 1967 by C. Maffei and Co. and placed in service in 1968, provides preliminary treatment—washing, crushing, and classifying—for the feldspar input material to the firm's six grinding mills in the Trento-Darzo area. Complete analytical laboratory facilities, including X-ray spectrometers and flame photometers, have been installed for close quality control to enable the final product, currently amounting to over 150,000 tons per year, to compete with flotation concentrate feldspar from sources in other European countries.

Table 6.—U.S. imports for consumption of feldspar [1]

Year	Crude		Ground	
	Long tons	Value (thousands)	Long tons	Value (thousands)
1966	-----	--------	3,243	\$86
1967	280	\$8	2,783	72
1968	-----	--------	3,377	91

[1] All from Canada, except 280 long tons (\$7,850) from Mexico and 22 long tons (\$767) from Sweden in 1967, and 121 long tons (\$4,770) from Sweden in 1968.

Norway.—The flotation process in use at the new plant of the Bjorum-Sibelco-Quarzwerke & Co. at Lillesand, where production was started in May 1968, yields three commercially valuable products—potash feldspar, soda feldspar, and glass-quality quartz—from pegmatitic granite feed. Current annual capacity of the facility is about 50,000 tons of feldspar, mostly for export to a number of destinations in Western Europe.

United Kingdom.—A British company started construction at Talke, Stoke-on-Trent, of a new plant scheduled for initial operation early in 1969 for the dry processing of high-grade hand-selected potash feldspar from mines at Lagares, Portugal. Demand for specialized ceramic applications is expected to keep the comparatively high-cost product competitive with other feldspathic materials produced less expensively elsewhere.

TECHNOLOGY

The practical literature on current feldspar beneficiation technology was augmented by a detailed description of the equipment and operation of a processing plant that, in addition to recovering substantial quantities of byproduct mica and silica sand, provides 200 tons per day of high-grade feldspar for glassmaking.[2]

---

[2] Morgan, E. R. The Feldspar Corporation's Middletown, Connecticut, Flotation Plant. Deco Trefoil (Denver Equipment Co.), v. 32, No. 2, Summer 1968, pp. 9–15.

Table 7.—World production of feldspar, by countries

(Long tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada (shipments)	8,169	9,736	9,754	9,280	9,560
Mexico	31,400	46,900	81,400	62,600	NA
United States (sold or used)	587,194	624,598	655,452	615,397	667,679
South America:					
Argentina	9,127	[r] 21,298	[r] 21,071	[p] 18,900	NA
Chile	814	517	1,174	857	920
Colombia	11,426	10,629	18,779	18,188	21,407
Peru	837	926	470	2,461	NA
Uruguay	883	1,227	1,722	1,242	91
Europe:					
Austria	1,603	1,397	1,507	2,441	2,140
Finland	14,665	11,684	25,901	34,472	[e] 50,000
France [2]	193,260	217,648	218,653	177,157	NA
Germany, West	299,989	313,280	285,796	261,464	NA
Italy	109,851	[r] 95,467	[r] 144,892	145,133	[e] 155,000
Norway [3]	70,022	62,985	86,748	[e] 85,000	NA
Poland [e]	26,000	26,000	28,000	28,000	28,000
Portugal	10,994	8,165	[r] 23,168	29,842	[e] 30,000
Spain	16,466	25,166	49,819	[e] 50,000	NA
Sweden	50,959	46,205	[r] 36,600	34,939	[e] 35,000
U.S.S.R. [e]	215,000	225,000	235,000	235,000	235,000
Yugoslavia	33,260	55,051	40,913	36,412	[e] 35,000
Africa:					
Angola	493	-----------	-----------	-----------	NA
Ethiopia	[e] 10,000	NA	1,526	-----------	7
Kenya	-----------	-----------	161	396	527
Mozambique	-----------	49	-----------	118	98
South Africa, Republic of	35,525	41,636	33,995	24,498	19,574
South-West Africa	1,893	2,281	1,178	[e] 1,200	NA
United Arab Republic	4,653	[e] 4,000	3,444	NA	1,691
Asia:					
Ceylon	[r] 49	605	412	252	577
Hong Kong	1,556	1,119	1,343	1,135	1,582
India	23,997	26,384	25,593	27,093	32,964
Japan [4]	61,445	57,244	50,845	49,906	65,101
Korea, South	13,468	15,595	15,052	16,551	20,661
Philippines	7,924	12,095	8,479	NA	NA
Oceania: Australia	9,012	8,724	7,260	4,450	[e] 4,400
Total [5]	[r] 1,861,934	[r] 1,973,611	[r] 2,116,107	[r] 1,974,384	NA

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Feldspar is produced in Brazil, Czechoslovakia, and Rumania, but data are not available.

[2] Includes pegmatite.

[3] Not including nepheline syenite (1964, 30,329; 1965, 40,369; 1966, 56,401; 1967, 65,900).

[4] In addition, the following quantities of aplite and other feldspathic rock were produced: 1964, 258,500 tons; 1965, 281,800 tons; 1966, 296,000 tons; 1967, 319,000 tons; 1968, 333,300 tons.

[5] Total is of listed figures only.

The greater part of the 1968 feldspar-related domestic and foreign patents that were reviewed described minor modifications of apparatus or procedures for the purpose of achieving improved flotation beneficiation of the mineral. Patents were issued in the United States and in Canada for an electrostatic separation process applicable to feldspar ores.

Many feldspar ores at pithead consist of more or less intimate mixtures of at least two of the commoner feldspar varieties, and while for the most part such mixtures are acceptable to industry without need of a prior separation, certain specialized purposes are best served by the essentially unmixed orthoclase or microcline feldspars formerly in adequate supply as hand-selected material from coarse-crystal pegmatites. The Bureau of Mines, anticipating the eventual depletion of many of the pegmatitic sources, has undertaken a study aimed at evolving technically and economically advantageous methods for obtaining the desired grades of high-potash feldspars by physical separation of the components of the very abundant naturally occurring mineral mixtures. Results from this research have been favorable thus far for some feed materials and hold promise for the eventual general success of the project.

NEPHELINE SYENITE

Nepheline syenite is a feldspathic material, low in quartz and consisting essentially of the alkali aluminum-silicate minerals, nepheline and feldspar, that is used in the production of glass and ceramics. In 1968 the U.S. demand for this mineral in the grades required for such applications was met entirely by imports, all from Canada, and which were 6 percent greater in quantity and 15 percent more in total value than during 1967, the record year hitherto. In 1967, the last year for which final figures have been released, the Canadian output of this material amounted to about 402,000 short tons, valued at over $4.7 million, of which approximately 72 percent by tonnage and 65 percent by value was exported to the United States. The October 1967 issue of Canadian Chemical Processing quoted nepheline syenite prices, for bagged material in carload lots, f.o.b. works, of $12 to $29 per short ton, slightly higher than in the preceding year. Early in 1968, the quoted price for Canadian glass-grade material in bulk, carload or truckload lots, f.o.b. plant, was increased from $10 per short ton to $11 per short ton. Ceramic Industry Magazine, January 1969 quoted 1968 U.S. prices of $19.50 per ton, high, and $8 per ton, low, presumably for the imported Canadian mineral.

Table 8.—U.S. imports for consumption of nepheline syenite

Year	Crude		Ground	
	Long tons	Value thousands	Long tons	Value thousands
1966	205	$3	253,230	$2,871
1967	-----	--------	256,837	3,104
1968	15	(1)	271,966	3,558

[1] Less than ½ unit.

APLITE

Aplite, a rock containing a high proportion of plagioclase feldspar, is employed chiefly as an ingredient in glass batch formulations. Because of its comparatively high iron content, aplite formerly was considered suitable for making only amber glass, but advancing technology has led increasingly to its widened acceptability and to its application in the manufacture of clear glass, as well, particularly for containers. Domestic production of aplite decreased in 1968 for the second successive year in regard to both tonnage and total value. Specific output figures are individual company confidential data, and cannot be published. Glass-grade aplite was mined in 1968 by International Minerals & Chemical Corp. and by M & T Chemical Inc., from operations respectively in Nelson and Hanover Counties, Virginia. Aplite prices published in Ceramic Industry Magazine, January 1969, were $7.80 per ton, high, and $5 per ton, low—not greatly changed from the corresponding quotations of January 1968, although producers reported substantially higher unit values for their mineral.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/1

Ferroalloys

By John W. Thatcher [1]

Ferroalloys consumption increased in 1968, reflecting an upswing in the production of raw steel and ferrous castings; however, ferroalloys production and shipments lagged behind those for 1967. The imbalance in U.S. ferroalloys foreign trade eased somewhat as imports for consumption decreased and exports reached a near record level. Technologic efforts were directed toward increased production efficiency through better furnace control and increased beneficiation of raw materials. New ferroalloys were marketed which improve traditional steelmaking operations and which meet the requirements created by new steelmaking processes.

More detailed information concerning the more important ferroalloys covered in this chapter may be found in the commodity chapters for individual alloying elements.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Government inventory of ferroalloys (stockpile grade), December 31, 1968

(Thousand short tons)

Alloy	National (strategic) stockpile	CCC and supplemental stockpile	Total
Ferrochromium:			
High-carbon	126	276	402
Low-carbon	127	191	318
Ferrochromium-silicon	26	33	59
Ferrocolumbium (contained columbium)	(1)	-----	(1)
Ferromanganese:			
High-carbon	143	1,033	1,176
Medium-carbon	30	-----	30
Ferromolybdenum (contained molybdenum)	4	-----	4
Ferrotungsten (contained tungsten)	1	-----	1
Ferrovanadium (contained vanadium)	1	-----	1

[1] Less than ½ unit.

Table 2.—Ferroalloys produced and shipped from furnaces in the United States

Alloy	1967				1968			
	Production		Shipments		Production		Shipments	
	Gross weight (short tons)	Alloy element contained, average percent	Gross weight (short tons)	Value (thousands)	Gross weight (short tons)	Alloy element contained, average percent	Gross weight (short tons)	Value (thousands)
Ferromanganese:[1]								
Blast furnace	667,655	78.0	609,182	$82,408	562,541	77.9	529,571	$73,455
Electric furnace [2]	273,272	78.4	261,599	45,954	317,421	78.2	303,589	54,654
Total	940,927	78.2	870,781	128,362	879,962	78.0	833,160	128,109
Silicomanganese	245,798	65.9	239,726	38,196	284,499	66.0	261,842	41,755
Ferrosilicon	673,535	56.6	603,415	102,010	665,383	56.6	609,158	102,647
Silvery iron:								
Blast furnace	52,133	9.5	47,769	3,730	28,414	8.6	41,676	3,425
Electric furnace	167,735	16.8	162,573	12,709	166,181	18.2	174,747	13,598
Total	219,868	15.1	210,342	16,439	194,595	16.8	216,423	17,023
Chromium alloys:								
Ferrochromium [3]	323,431	67.6	299,333	81,978	281,697	69.2	271,679	71,701
Other chromium alloys [4]	122,706	42.5	92,890	23,010	107,875	45.6	88,665	19,496
Total	446,137	60.7	392,223	104,988	389,572	62.6	360,344	91,197
Ferrotitanium	3,116	25.2	3,704	2,417	4,130	26.6	4,400	3,656
Ferrophosphorus	123,510	24.5	106,987	6,091	116,723	23.0	80,186	2,490
Ferrocolumbium and ferrotantalum-columbium	1,792	54.7	1,720	6,678	2,148	55.4	1,981	7,695
Other [5]	94,822	36.0	78,824	59,407	84,049	40.6	76,220	161,193
Grand total	2,749,505	59.5	2,507,722	464,588	2,621,061	60.6	2,443,714	[6] 555,764

[1] Includes briquets.

[2] Includes fused-salt electrolytic.

[3] Includes low- and high-carbon ferrochromium and chromium briquets.

[4] Includes ferrochrome-silicon, exothermic chromium additives, and other chromium alloys.

[5] Includes Alsifer, ferroboron, ferronickel, ferromolybdenum, ferrotungsten, ferrovanadium, simanal, spiegeleisen, zirconium-ferrosilicon, ferrosilicon-zirconium, and other miscellaneous ferroalloys.

[6] Data may not add to totals shown because of individual rounding.

DOMESTIC PRODUCTION

In 1968, 31 producers reported production of 2.6 million tons of ferroalloys, a 5-percent decrease compared with that for 1967. Among the major steelmaking ferroalloys, production trends were inconsistent; production of ferromanganese and ferrochromium decreased 6 and 13 percent, respectively, while ferrosilicon production decreased slightly from the 1967 level and production of silicomanganese rose 14 percent. Shipments of ferromanganese and silicomanganese, both historically dependent on steel production, also went in opposite directions; ferromanganese shipments decreased 4 percent and silicomanganese shipments increased 8 percent. Shipments of chromium alloys decreased 8 percent, reflecting a drop in the production of stainless steel, while shipments of ferrosilicon showed a slight increase. Total shipments of ferroalloys dropped 3 percent from those of 1967.

Of the 18 States which produced ferroalloys, Ohio, Pennsylvania, and West Virginia accounted for more than half of the total domestic production. Production was also reported from Alabama, Florida, Idaho, Iowa, Kentucky, Montana, New Jersey, New York, Oregon, South Carolina, Tennessee, Texas, Virginia, and Washington.

Most of the ferroalloys were produced in electric furnaces, although the blast furnace was used to produce large tonnages of low-grade ferromanganese and ferrosilicon. The high-melting-point ferroalloys, which are essential for making specialty steels, were produced mainly by aluminothermic methods.

Foote Mineral Co. announced a new organizational structure resulting from its merger with Vanadium Corporation of America (VCA) in 1967. Effective February 8, Foote Mineral Co. began operating as three divisions, each functioning as a separate profit center. These were identified as the Chemicals and Minerals Division, Metallurgical Products Division, and the Kemco Division. The Metallurgical Products Division, a combination of the Vancoram operations (formerly Vanadium Corporation of America) and the electrolytic manganese operations, produces and markets chromium, silicon, and vanadium ferroalloys; electrolytic manganese; and various proprietary alloys. The Kemco Division, at one time the Keokuk Electro-Metals Co. (a division of VCA prior to the merger) produces silicon metal and ferrosilicon. The new 54,700-kilovolt-ampere ferrosilicon furnace which was completed late in 1967 at the Graham, W. Va., plant, reached full design capacity after unanticipated engineering and technological difficulties were resolved during the first half of the year.

In April, Air Reduction Co., Inc., (Airco) acquired a 75-percent interest in Wargöns a.-b., an important Swedish producer of chromium, manganese, and silicon ferroalloys, and of paper products. Improvement programs at Airco's domestic plants in 1968 included major additions to furnace facilities underway at Calvert City, Ky., and Niagara Falls, N.Y., which when completed will increase ferroalloys production capacity about 30 percent at each location. A new 25,000-kilovolt-ampere furnace was under construction at the Charleston, S.C., plant, and will be in operation near the end of 1969.

In the second half of the year, the Mining and Metals Division of Union Carbide Corp. completed installation at Marietta, Ohio, of a 30,000-kilovolt-ampere furnace for the production of silicomanganese alloys. Additionally, a chromium alloy furnace of comparable size is scheduled for operation at Marietta early in 1969.

Table 3.—Producers of ferroalloys in the United States in 1968

Producer	Plant location	Product [1]	Type of furnace
Agrico Chemical Co	Pierce, Fla	FeP	Electric.
Air Reduction Co., Inc., Airco Alloys & Carbide Div.	Calvert City, Ky Charleston, S.C Niagara Falls, N.Y	FeCr, FeMn, FeSi, SiMn, silvery iron.	Do.
Bethlehem Steel Co	Bethlehem, Pa	FeMn	Blast.
Calumet & Hecla Corp	Selma, Ala	FeSi	Electric.
Chromium Mining & Smelting Co.	Woodstock, Tenn	FeMn, SiMn, FeSi, FeCr.	Do.
Climax Molybdenum Co	Langeloth, Pa	FeMo	Aluminothermic.
FMC Corp	Pocatello, Idaho	FeP	Electric.
Foote Mineral Co	Cambridge, Ohio Graham, W. Va Keokuk, Iowa Vancoram, Ohio Wenatchee, Wash	FeB, FeCb, FeTi, FeV, FeCr, FeMn, FeSi, SiMn, silvery iron, other.[2]	Do.
Hanna Furnace Corp	Buffalo, N.Y	Silvery iron	Blast.
Hanna Nickel Smelting Co	Riddle, Oreg	FeNi	Electric.
Hooker Chemical Corp	Columbia, Tenn	Fep	Do.
Interlake Steel Corp	Beverly, Ohio	FeCr, FeSi, SiMn	Do.
Jackson Iron & Steel Co	Jackson, Ohio	Silvery iron	Blast.
Kawecki Chemical Co	Easton, Pa	FeCb	Aluminothermic.
E. J. Lavino & Co	Sheridan, Pa	FeMn	Blast.
Manganese Chemical Corp	Kingwood, W. Va	do	Electric.
Mobil Chemical Co	Charleston, S.C Mount Pleasant, Tenn Nichols, Fla	FeP	Do.
Molybdenum Corp. of America.	Washington, Pa	FeMo	Electric and aluminothermic.
Monsanto Chemical Co	Columbia, Tenn Soda Springs, Idaho	FeP	Electric.
National Lead Co	Niagara Falls, N.Y	FeCbTi, FeTi, other [2]	Do.
New Jersey Zinc	Palmerton, Pa	Spln	Do.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeCr, FeSi, FeB, Fe Mn	Do.
	Philo, Ohio	SiMn	Blast.
	Powhatan, Ohio	SiMn	Electric.
	Tacoma, Wash	SiMn	Do.
Reading Alloys	Robesonia, Pa	FeB, FeCb, FeV, NiCb, FeMo.	Aluminothermic.
Shieldalloy Corp	Newfield, N.J	FeV, FeTi, FeB, FeMo, FeCb, FeCbTa, other. [2]	Do.
Stauffer Chemical Co	Mount Pleasant, Tenn Silver Bow, Mont Tarpon Springs, Fla	FeP	Electric.
Tennessee Alloys Corp	Bridgeport, Ala	FeSi	Do.
Tennessee Valley Authority	Muscle Shoals, Ala	FeP	Do.
Tenn-Tex Alloy Corp of Houston.	Houston, Tex	FeMn, SiMn	Do.
Union Carbide Corp	Alloy, W. Va	FeB, FeCr, FeCb, FeSi	Electric and aluminothermic.
	Ashtabula, Ohio	FeMn, FeTi, FeW, FeV	Electric.
	Marietta, Ohio	SiMn, other [2]	
	Niagara Falls, N.Y	SiMn, other [2]	
	Portland, Oreg	SiMn, other [2]	
	Rockwood, Tenn	SiMn, other [2]	
	Sheffield, Ala	SiMn, other [2]	
United States Steel Corp	Birmingham, Ala Clairton, Pa Duquesne, Pa	FeMn	Blast.
Woodward Iron Co	Woodward, Ala	FeSi	Electric.

[1] FeMn, ferromanganese; Spln, spiegeleisen; SiMn, silicomanganese; FeSi, ferrosilicon; FeP, ferrophosphorus; FeCr, ferrochromium; FeMo, ferromolybdenum; FeNi, ferronickel; FeTi, ferrotitanium; FeW, ferrotungsten; FeV, ferrovanadium; FeB, ferroboron; FeCbTa, ferrocolumbium-tantalum; FeCb, ferrocolumbium; NiCb, nickel columbium; Si, silicon metal; FeCbTi, ferrocarbontitanium.

[2] Includes Alsifer, Simanal, zirconium alloys, ferrosilicon boron, aluminum silicon alloys, and miscellaneous ferroalloys.

CONSUMPTION

Consumption of ferroalloys both as a process additive and as an alloying ingredient increased 3 percent in 1968, reflecting a 4-percent increase in steel production and a 6-percent increase in the production of ferrous castings. A comparison of the total ferroalloys consumption for 1968 with that for 1967 is only approximate because of a deviation in 1967 from the standard method for reporting ferrochromium consumption. In 1967, the ferrochromium consumed was reported in gross weight as an additive (Table 4) rather than in contained weight as an alloying element (Table 5), owing to the lack of reporting of chromium content data by respondents. Assuming that the elemental content of the ferrochromium consumed in 1967 was the same as that reported for chromium alloys shipped (60.7 percent), ferrochromium consumption in

1967 expressed as contained element was then 223,175 tons and the consumption of ferroalloys as additives and as alloying elements in 1967 was then 1,963,527 tons and 235,754 tons, respectively.

Approximately 70 percent of the total ferroalloy demand was consumed by the steel industry, and 15 percent by foundries. The remainder was consumed in a wide range of uses including that unspecified by respondents.

Table 4.—Consumption by end use of ferroalloys as additives in the United States in 1968

(Short tons)

Alloy	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels [2]	Cast irons	High-temperature alloys	Other uses [3]	Total
Ferromanganese [4]	10,517	133,690	801,338	3,574	28,040	621	98,485	1,076,265
Silicomanganese	10,221	30,606	107,890	639	2,388	(5)	12,888	164,632
Silicon alloys [6]	23,106	83,127	172,358	3,016	382,652	662	93,972	758,893
Ferrotitanium	365	700	1,657	6	(5)	173	186	3,087
Ferrophosphorus	13	1,924	10,154	(5)	678	-----	356	13,125
Ferroboron	(7)	67	(5)	-----	7	(5)	185	259
Total	44,222	250,114	1,093,397	7,235	413,765	1,456	206,072	2,016,261

[1] Includes steel mill rolls.
[2] Includes high speed, hot work tool, and other tool steels.
[3] Includes unspecified uses.
[4] Includes spiegeleisen, manganese metal, and briquets.
[5] Included with "Other uses."
[6] Includes silicon metal and silvery iron. See Silicon chapter for more detail.
[7] Included with "Other alloy steels."

Table 5.—Consumption by end uses of ferroalloys as alloying elements in the United States in 1968

(Short tons of contained elements)

Alloy	Stainless steels	Other alloy steels [1]	Carbon steels	Tool steels [2]	Cast irons	High-temperature alloys	Other uses [3]	Total
Ferrochromium [4]	154,618	43,912	6,156	3,820	3,990	8,499	8,586	229,581
Ferromolybdenum [5]	913	874	147	532	1,364	299	734	4,863
Ferrotungsten	70	100	------	478	------	72	56	776
Ferrovanadium [6]	45	2,603	1,092	561	29	36	875	5,241
Ferrocolumbium	221	664	272	2	------	337	27	1,528
Ferrotantalum-columbium	14	1	------	------	------	------	9	24
Total	155,881	48,154	7,667	5,393	5,383	9,243	10,287	242,008

[1] Includes steel mill rolls.
[2] Includes high speed, hot work tool, and other tool steels.
[3] Includes unspecified uses.
[4] Includes other chromium ferroalloys and chromium metal.
[5] Includes calcium molybdate and molybdenum silicide.
[6] Includes other vanadium-carbon-iron ferroalloys.

STOCKS

Stocks of most ferroalloys were good at the beginning of the year as producers had built up large inventories late in 1967 in anticipation of heavy demand during the first half of 1968. Lead times for delivery were generally short, although some tightness was reported in supply of ferrochromium and ferronickel. When the demand for ferroalloys lessened, after the steel contract settlement on August 1, producers and consumers allowed their inventories to be worked down.

In addition to producer and consumer stocks, large inventories of ferroalloys were stored in various Government stockpile programs.

Table 6.—Stocks of ferroalloys held by producers and consumers in the United States, December 31, 1968

(Short tons)

Alloy	Producer		Consumer	
	1967, gross weight	1968, gross weight	1967, gross weight	1968, gross weight
Manganese ferroalloys [1]	215,427	59,254	r 176,807	141,672
Silicon alloys [2]	145,175	82,718	r 65,807	67,352
Ferrochromium [3]	123,754	58,869	r 37,155	29,176
Ferrotitanium	1,303	1,084	664	712
Ferrophosphorus	61,365	91,320	8,707	2,270
Ferroboron	201	167	51	70
Total	547,225	493,412	r 289,191	241,252
	1967, contained element	1968, contained element	1967, contained element	1968, contained element
Ferromolybdenum [4]	W	W	r 1,144	1,049
Ferrotungsten	W	W	r 186	172
Ferrovanadium	r 673	2,591	r 1,132	942
Ferrocolumbium	r 475	597	341	281
Ferrotantalum-columbium	W	---------	11	8
Total	r 1,922	3,188	r 2,814	2,452

r Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Includes ferromanganese, silicomanganese, spiegeleisen, manganese metal and briquets.
[2] Includes ferrosilicon, silvery iron and miscellaneous silicon alloys. Consumers stocks also include silicon metal.
[3] Includes other chromium ferroalloys and chromium metal.
[4] Includes calcium molybdate and molybdenum silicide.

PRICES

The quoted price of domestically produced standard high-carbon ferromanganese remained unchanged in 1968 at $164.50 per long ton, f.o.b. furnaces, for lump bulk material in carload lots. Prices for imported material were variously quoted from $142 to $147 per long ton, delivered in Pittsburgh or Chicago. The average value at furnaces for all grades of ferromanganese shipped by domestic producers increased from $147.41 per short ton in 1967 to $150.30 per short ton in 1968.

The prices of chromium alloys were unchanged throughout most of the year; however, late in December prices of high-carbon ferrochromium, charge chrome, and blocking chrome were increased 0.4 cent per pound of contained chromium. Imported high-carbon ferrochromium was quoted about 3 cents lower per pound of contained chromium than domestic material, and imported charge chromium was quoted about 1 cent per pound lower than domestic.

The price of the 50-percent grade of ferrosilicon, which had remained at 13.1 cents per pound of contained silicon since the second quarter of 1966, was raised, effective April 1, to 13.5 cents f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk. Announcements of a further increase in the price of this grade to 13.8 cents per pound of contained silicon, same basis, effective January 2, 1969, were made by two major producers at yearend. Price increases, effective January 2, 1969, were also announced for ferroaluminum-silicon, silicon briquets, silicon-manganese-zirconium alloys, calcium-silicon, and zirconium-silicon.

All grades of ferrovanadium were quoted throughout the year at $2.90 per pound of contained vanadium, f.o.b. shipping point with freight equalized to nearest main producer. The new vanadium-iron alloy, Solvan, which was introduced by Foote Mineral Co. in July, was quoted at $2.46 per pound of contained vanadium, the same price as Carvan, a vanadium-iron alloy first marketed by Union Carbide Corp. in 1964.

In line with price moves by other producers, the Hanna Mining Co. announced in December that the price of ferronickel would be raised 9 cents per pound to \$1.005 per pound of contained nickel, f.o.b. shipping point, to be effective January 2, 1969.

The quoted prices for low-carbon ferrotitanium (25 to 40 percent Ti) and ferrotungsten remained unchanged from 1966 through 1968, at \$1.35 and \$3 nominal per pound, respectively. The 1967 price for ferromolybdenum, \$2.11 per pound of molybdenum basis, held throughout 1968, as did the price range quoted for standard ferrocolumbium, \$2.45 to \$2.60 per pound of columbium, ton lots, f.o.b. shipping point.

FOREIGN TRADE

The world market for ferroalloys strengthened in 1968 as steel production increased in every major producing country. The United States remained a net importer of ferroalloys; however, exports gained ground on imports. Volume of exports increased 66 percent to a near record level, while value increased 22 percent to establish 1968 as the best year for foreign sales in the history of the industry. Exports of ferrochromium about doubled to lead in foreign sales of the major steelmaking ferroalloys. The United Kingdom, a ferroalloys-poor country, took 30 percent of the ferrochromium exports. Exports of ferromanganese also doubled, but remained relatively small. Exports of ferrosilicon increased 56 percent and were distributed as follows: Canada and West Germany, 36 percent each; United Kingdom, 17 percent; and the remainder, in order of decreasing tonnage, going to Sweden, Mexico, Turkey, Australia, and other countries. The large volume of ferrophosphorus shipments, which contributed little to total export value, went principally to West Germany, presumably for use in the production of fertilizers.

The net trend in imports for consumption of ferroalloys continued downward for the second consecutive year, although there were deviations from the trend line among the individual ferroalloys. High-carbon ferromanganese, making up the bulk of the imports, decreased 3 percent on a gross weight basis and 17 percent on a value basis. Similarly, imports of low and medium-carbon ferromanganese decreased. Imports of low-carbon ferrochromium increased somewhat while imports of silicomanganese decreased 27 percent on a weight basis and 35 percent on a value basis from those for 1967. Although small relative to total imports, and historically erratic, imports for consumption of ferronickel increased by a factor of 4 over those for 1967, while imports of ferrovanadium increased by a factor of 148. Principal suppliers for imported ferromanganese were France, the Republic of South Africa, West Germany, India, United Kingdom, Gabon, and Sweden, in order of decreasing tonnage. The principal supplier of ferrosilicon was Canada, followed by Japan, France, Southern Rhodesia, and the Republic of South Africa.

Table 7.—U.S. exports of ferroalloys

Alloys	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ferrocerium and alloys	31	\$209	71	\$303	45	\$303
Ferrochromium	7,647	1,870	13,453	3,479	27,127	5,735
Ferromanganese	545	228	1,861	760	3,710	645
Ferromolybdenum	1,100	4,085	767	2,436	432	1,194
Ferrophosphorous	62,942	2,975	22,901	847	36,708	930
Ferrosilicon	5,812	2,004	11,774	3,228	18,372	4,481
Ferrovanadium	482	2,209	351	1,398	278	1,052
Ferroalloys n.e.c	7,301	2,381	7,976	5,757	11,288	7,814
Total	85,860	15,961	59,154	18,208	97,960	22,154

Table 8.—U.S. imports for consumption of ferroalloys and ferroalloy metals

Alloy	1967			1968		
	Gross weight (short tons)	Content (short tons)	Value (thousands)	Gross weight (short tons)	Content (short tons)	Value (thousands)
Chromium metal	r 1,214	(1)	r $1,842	1,366	(1)	$2,053
Ferrocerium and other cerium alloys	(2)	(1)	(1)	12	(1)	77
Ferrochrome and ferrochromium—						
Containing 3 percent or more carbon	r 8,690	5,646	1,350	8,259	5,229	1,239
Containing less than 3 percent carbon	48,969	32,827	12,408	51,557	35,780	12,958
Ferromanganese—						
Containing not over 1 percent carbon	5,106	4,497	2,102	3,269	2,845	1,100
Containing over 1 and less than 4 percent carbon	21,669	17,817	4,298	17,988	14,910	3,559
Containing not less than 4 percent carbon	r 189,504	r 145,298	r 20,037	183,097	141,834	16,578
Ferromolybdenum, molybdenum metal, compounds, alloys and scrap (molybdenum content)	1,175	690	2,485	238	218	1,043
Ferronickel	2,600	(1)	1,110	10,553	(1)	5,450
Ferrosilicon	30,333	15,337	4,456	24,901	10,622	3,211
Ferrosilicon chromium	-------	-------	-------	1,932	(1)	339
Ferrosilicon manganese (manganese content)	34,936	r 23,455	4,106	25,412	16,885	2,680
Ferrotitanium and ferrosilicon titanium	153	(1)	85	199	(1)	143
Ferrovanadium	8	(1)	37	1,185	(1)	1,756
Ferrozirconium	726	(1)	260	292	(1)	105
Manganese metal	2,337	(1)	919	3,183	(1)	1,253
Tungsten alloys (unwrought) and scrap (tungsten content)	(2)	(2)	2	5	2	15
Tungsten metal (lump, grains, or powder) and tungsten carbide (tungsten content)	(1)	5	63	(1)	8	105
Tungstic acid and other alloys of tungsten not specifically provided for (tungsten content)	31	22	260	22	14	172
Ferroalloys not elsewhere classified	r 536	(1)	r 1,217	692	(1)	1,507

r Revised.

[1] Not recorded.

[2] Less than ½ unit.

WORLD REVIEW

Japan.—Highlights for the year were implementation of modernization and expansion programs for ferroalloy plants and technological advances in the production of ferrochromium. Just 14 years ago the productivity of the Japanese ferroalloy industry was among the world's lowest. In 1954, 38 ferroalloy producers operated 266 electric furnaces, of which 169 were in the 1,000-kilovolt-ampere or smaller category and the five largest were in the 7,000-kilovolt-ampere class. When ferroalloy trade was liberalized in 1962, Japanese annual output per producer was only 11,000 tons compared with 17,000 tons for India and 33,000 tons for producers in the United States. Of the 307 electric furnaces in operation that year, 85 were still in the 1,000-kilovolt-ampere class and 150 others were smaller than 5,000 kilovolt-amperes each. Under the urging of the Ministry of International Trade and Industry (MITI), Japanese producers began to merge and to replace old, small furnaces with new, larger, and more efficient furnaces. Of Japanese industries producing metal in 1968, the ferroalloy industry was second in size only to the iron and steel industry.

Modernization and expansion programs underway in 1968 involved not only the installation of larger furnaces but also the construction of new ferroalloy plants adjacent to steelworks for supplying molten ferroalloys and thus insuring fully integrated steelmaking operations. This is particularly evident in construction of new ferrochromium plants adjacent to stainless steel producers. In addition to the general growth and improvement of the industry, a noteworthy technological innovation was the development of a new ferrochromium formula by Showa Denko K.K. which reportedly cuts electric power consumption to one-half that using the conventional method and cuts overall costs by about 20 percent.

Of the 1.2 million short tons of ferroalloys produced in Japan in 1968, ferromanganese accounted for about 380,000 tons, silicomanganese, 209,000 tons, ferrosilicon 184,000 tons, ferrochromium 236,000 tons and ferronickel 148,000 tons. Production of ferrosilicon and ferrochromium was less than anticipated due to a shortage of electric power caused by a drought late in the year.

Norway.—The production of ferrosilicon increased by about 68,000 short tons during 1968, due mainly to the installation of a new furnace at the Salten plant of Elektrokemisk A/S in northern Norway. Production of ferromanganese increased by about 38,600 tons as a result of the addition of a new furnace at the Porsgrunn Elektrometallurgiske A/S plant owned by Elektrokemisk A/S. Norwegian ferroalloy production in 1968, in short tons, was as follows:

Ferrosilicon	385,000
Ferromanganese	187,000
Ferrochrome	37,000
Other ferroalloys:	
Ferrosilicochrome	6,000
Ferrosilicon briquets	6,600
Ferrosilicomagnesium	2,400
Ferrosilicomanganese	149,000
Miscellaneous	3,100
Total	776,100

Norway is now the world's largest producer of silicon carbide as a result of plant expansions completed by the following three producers: Arendal Smelteverk, Eydehamn; Orkla Exolon, Orkanger (U.S. owned); and Norton Norge, Lillesand (U.S. owned).

Turkey.—Among the projects under study by Etibank, a leading mining and smelting state enterprise, is a ferrochromium plant at Keban-Guleman in southeastern Turkey.

TECHNOLOGY

Technological highlights included innovations in ferroalloy production methods, improvements in standard production techniques, technologic trends in steel production which affect ferroalloys use, and new ferroalloys developed and marketed which improve the economics or technology of certain steelmaking processes.

The rapid growth in demand for ferroalloys, high production costs, particularly for electric power, and the growing concern about air pollution have stimulated recent innovations in ferroalloy production in Japan. Innovations have been particularly evident in the treatment of manganese ore for the production of ferromanganese. A limited number of producers—for example, the Sakata plant of Ferroalloy Industry, Ltd.,—dry the raw material in a rotary dryer through effective use of gas emanating from semiclosed silicon-manganese electric furnaces. At the Kanazawa Plant of Nihon Denko, Ltd., powdery manganese ore composed predominantly of mudlike ore such as that of U.S.S.R. origin, purchased at a low unit price, is sintered by the Dwight-Lloyd (D–L) sintering process. The sintered ore obtained in this manner accounts for about 40 to 50 percent of the raw material consumed at the plant. A noteworthy advantage derived from the use of sintered ore is that the amount of dust produced by the electric furnace is small. The low average consumption of electrical power at the plant, 2,130 kilowatt-hours per short ton of ferromanganese produced, compares favorably with the average consumption for the industry which ranges from 2,450 to 2,540 kilowatt-hours per ton.

At the Mizushima Plant of Mizushima Gokin-Tetsu and the Takaoka Plant of Azuma Kako, Ltd., the process of preheating ore is employed to increase the efficiency of producing high-carbon ferromanganese. At the Mizushima Plant, the ore is heated in a shaft furnace to 200°–300° C, by introducing burnt reducing gases from the electric furnace. Laboratory and pilot plant tests at the Takaoka Plant of Azuma Kako, Ltd., confirmed that the most critical parameter in preheating manganese ore is the selection of preheating temperature. The tests further showed that the optimum preheat temperature is 950° C. After scaling-up the pilot plant preheating equipment and integrating it with the operation of a 8,500-kilovolt-ampere ferromanganese furnace, the power consumption of the furnace dropped from 2,360 kilowatt-hours per ton to 1,900 kilowatt-hours per ton. An additional improvement was the reduction of dust generation from the electric furnace.[2]

---

[2] Tanabe, Isso. Preheating of Ore for a Ferromanganese Furnace—A Recent Trend in Japan. J. Metals, v. 20, No. 5, May 1968, pp. 81–87.

Ore preheating plus sintering will be used in a new technique developed by Showa Denko K.K., the leading Japanese ferrochromium producer, in a new plant at Tokuyama which will go onstream late in 1969. The new technique is expected to cut electric power consumption to one-half that for a conventional plant and to reduce overall costs by 20 percent. An annual output of 60,000 tons of low-carbon ferrochromium is expected from a modest 18,000-kilovolt-ampere furnace. A second furnace to be installed later will boost annual output to 100,000 tons. In the new process, chromium ore is preheated and sintered in a rotary kiln and then charged hot and continously to an electric furnace. The production of the Tokuyama plant will be integrated with that of an adjacent steel plant; molten ferrochromium will be transported "over-the-fence" to Nisshin Steel's stainless steel furnaces.

Factors critical to efficient production of ferromanganese and silicomanganese were delineated in an article describing the operation of the large, closed, rotating, Elkem electric furnaces at the Tasmanian Electro Metallurgical Co.'s plant at Bell Bay, Tasmania, Australia.[3]

The differences in physical chemistry between blast furnace production of pig iron and blast furnace production of ferromanganese were reviewed. The following conclusions were reached concerning the operation of a ferromanganese blast furnace:

1. Large quantities of heat in the enthalpy range higher than 2,800° F are important.

2. High flame temperature from the use of high hot-blast temperature and oxygen enrichment decreased total fuel requirement.

3. The use of slag compositions that permit high ratios of bases to silica without impairing fluidity are conducive to high manganese recovery.[4]

Union Carbide Corp. announced a new process for making stainless steel involving the simultaneous injection of argon and oxygen into a refining vessel separate from the arc furnace. The major cost-saver in the process is that more high-carbon ferrochrome—the least expensive kind—can be used. In present practices, when low-cost chromium is included in the charge, decarburization with oxygen also oxidizes considerable chromium so that the amount of low-cost chromium used must be restricted. In the new process, argon injection during decarburization promotes carbon removal with minimum effect on chromium. This permits adding to the furnace charge essentially all the chromium needed in the final product as low-cost, high-carbon ferrochrome. Since very little of this is oxidized during decarburization, the need for low-carbon ferrochrome later in the refining process is very substantially reduced.[5]

Union Carbide also introduced a new high-carbon ferrochrome designed to dissolve readily in basic oxygen and open hearth heats at normal steelmaking temperatures, thus improving furnace operations, alloy recoveries, and analysis control, according to the company. Rapid solution of ferrochrome is particularly desirable in basic oxygen practice as large additions to the ladle are favored over additions to the furnace to avoid oxidation of chromium into the furnace slag. Laboratory studies showed that the fastest solution rates were obtained with a ferrochrome containing 5 percent manganese and minimal silicon.

A new vanadium-iron alloy, Solvan, was patented in 1968 by Foote Mineral Co. and tested extensively in steelplants in the United States and Canada. According to the producer, the tests confirmed the technical and economic advantages of the alloy, and commercial production was started in early 1969. Typically containing 25 percent vanadium, Solvan is characterized by high density, improved solubility, and good homogeneity. A low carbon level of 0.30 percent maximum allows the use of lower cost ferromanganese in the steel melt, and the low oxygen content provides a ferrovanadium alloy with a minimum of nonmetallic inclusions, thus contributing to the production of cleaner steels. Vanadium is used as a deoxidizer and grain refiner in continuously cast steels, and as a strengthening agent in high-strength, low-alloy structural steels and large-diameter, high-pressure piping for pipelines. All three uses are among the fastest growing in the steel industry.

---

[3] Hooper, Rex T. The Production of Ferromanganese. J. Metals, v. 20, No. 5, May 1968, 88–92.

[4] Stephenson, R. L. The Use of Physical Chemistry in Controlling the Operation of a Blast Furnace Producing Ferromanganese. J. Metals, v. 21, No. 2, February 1969, pp. 49–52.

[5] Iron and Steel Engineer. Revolutionary Process Developed for Making Stainless Steels. V. 45, No. 10, October 1968, pp. 137–138.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/96

Fluorspar and Cryolite

By J. Robert Wells[1]

FLUORSPAR

Demand for both acid and metallurgical grades of fluorspar in the United States maintained a strong upward trend throughout 1968, and for the first time in history the quantity imported for consumption (all grades) reached a figure in excess of 1 million tons, or somewhat more than 80 percent of the Nation's total requirements for the year. Much of the increased demand for acid-grade fluorspar was a reflection of the growing use of a multitude of versatile fluorocarbon plastics. In steel manufacturing, although there was a continued contraction in consumption of metallurgical spar in open-hearth furnaces, that used in basic-oxygen installations continued to increase.

Legislation and Government Programs.—No contracts for exploration of fluorspar prospects were made by the Office of Minerals Exploration during the year. The General Services Administration reported that, of 14,600 tons of fluorspar held by the Government and previously declared surplus, 4,500 tons was sold by sealed bids in October and that the remainder, except for 1,429 tons immobilized by cold weather at the Colorado storage site, was disposed of subsequently in negotiated transactions. The Office of Emergency Preparedness announced in December that 210,533 tons of fluorspar in inventory was considered excess to stockpile requirements and requested legislative authorization for disposing of this surplus material at a rate not to exceed 25,000 tons during the program's first year. Government inventories as of December 31, 1968 included 1,123,858 tons of stockpiled acid-grade fluorspar and 412,243 tons classed as metallurgical-grade material.

DOMESTIC PRODUCTION

The region embracing Hardin and Pope Counties, Ill., and Crittenden, Livingston,

Table 1.—Salient fluorspar statistics

	1964	1965	1966	1967	1968
United States:					
Production:					
Crude:					
Mine production....short tons..	620,474	772,765	737,411	838,631	749,219
Material milled or washed..do....	624,745	825,867	796,418	914,616	765,531
Beneficiated material recovered........short tons..	202,300	236,800	250,200	284,300	237,000
Finished (shipments).........do....	217,137	240,932	253,068	295,643	252,411
Value.................thousands..	$9,723	$10,889	$10,841	$13,164	$11,656
Exports...................short tons..	3,702	9,385	5,732	10,345	12,614
Value....................thousands..	$158	$315	$301	$517	$496
Imports for consumption....short tons..	687,933	816,546	878,546	911,870	1,050,107
Value....................thousands..	$16,882	$19,958	$21,968	$24,485	$28,699
Consumption................short tons..	831,561	930,127	1,065,124	1,091,158	1,243,414
Stocks Dec. 31:					
Domestic mines:					
Crude.............short tons..	299,109	274,011	207,338	126,716	97,522
Finished.................do....	10,174	19,664	26,589	22,522	12,557
Consumer plants..............do....	203,014	235,657	254,726	303,718	328,121
World: Production......................do....	2,717,106	3,052,970	3,131,203	3,502,094	NA

NA Not available.

---

[1] Physical scientist, Division of Mineral Studies.

and Caldwell Counties, Ky., continued to be the most productive source of domestic fluorspar. Operations in this area depended, as usual, on the coproduct relationship of fluorspar, lead, and zinc from the same mines. Smaller tonnages of fluorspar, with no byproduct involvement, were contributed by Colorado, Montana, Nevada, New Mexico, and Utah.

The 1968 domestic output figures, both for production and for shipments, were substantially below those of 1967.

The Aluminum Company of America (Alcoa) discontinued the milling of fluorspar at Rosiclare, Ill., early in 1968, and the Pennsalt Chemicals Co. mill at Mexico, Ky., suspended its operations some months later. Substantially more than an eventual counterbalance for these closures was promised by the resumption of mining and milling activities at the properties of the Obark-Mahoning Co. at Northgate, Colo. This establishment, not yet in full operation at yearend, has the potential of adding at least one-fifth more to the total domestic output of fluorspar.

At Polk City, Ill., the Minerva Co. began hoisting 250 tons of fluorspar ore per day from the vertical 6- by 13-foot Gaskins shaft, which was bottomed at 534 feet. The company's use at this location of specially designed limited-width loader-haulers is the first reported underground application of rubber-tired hauling equipment in fluorspar mining.

Enthusiastic acceptance by users assured a permanent place in the industry for fluorspar briquets and pellets, the production of which continued to gain momentum. Although existing plants operated at or near capacity throughout most of the year, the demand for both acid and metallurgical grade agglomerates far outran the supply, giving rise to active consideration of plans for expanding existing installations and programs for constructing additional facilities elsewhere.

CONSUMPTION AND USES

Consumption in the United States of all grades of fluorspar in 1968, as indicated by a canvass of principal users, reached a total of 1.2 million tons, a new annual record. Although the comparison with earlier figures is not strictly valid because of a difference in the methods by which the data were collected, consumption was at least 10 percent more than in any previous year. Approximately 80 percent of the fluorspar consumed in 1968 was imported, and only 20 percent came from domestic sources.

PRICES

The December 1968 issue of Engineering and Mining Journal quoted the following prices per short ton for the principal commercial grades of fluorspar:

Domestic, f.o.b. Illinois-Kentucky:	
Metallurgical-grade, 72½ percent effective CaF_2	$41.50–42.50
Acid-grade concentrates, dry basis, 97 percent CaF_2:	
Carloads	54.00
Less than carloads	55.00
Bags, extra	4.00
Pellets, 70 percent effective CaF_2	46.50
Ceramic-grade, 95 to 96 percent CaF_2	51.50
European:	
Acid-grade, duty paid, dry basis	44.50–47.00
Mexican:	
Metallurgical-grade, 72½ percent effective CaF_2:	
Border, all rail, duty paid	33.00–34.00
Brownsville, Tex., barge, duty paid	35.00–36.50
Tampico, Mexico, vessel cargo lots	27.00–27.50
Acid-grade, 97+ percent, Eagle Pass, Tex., bulk	40.00–41.00

Table 2.—Shipments of finished fluorspar, by States

State	1967			1968		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per ton		Total (thousands)	Average per ton
Arizona	10,000	$280	$28.00	--------	--------	--------
Illinois	210,207	9,859	46.90	188,325	$9,134	$48.50
Kentucky	32,952	1,686	51.17	17,050	878	51.48
Utah	W	W	W	8,762	218	24.82
Other States [1]	42,484	1,339	31.52	38,274	1,431	37.40
Total [2]	295,643	13,164	44.53	252,411	11,656	44.42

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes Colorado, Montana, New Mexico, and Nevada.

[2] Data may not add to totals because of independent rounding.

Table 3.—Fluorspar (domestic and foreign) consumed and in stock in the United States, by grade and use in 1968

Grade and use	Short tons
CONTAINING MORE THAN 97 PERCENT CALCIUM FLUORIDE	
Hydrofluoric acid	659,524
Glass	7,789
Enamel	425
Nonferrous metals	6,274
Iron foundry	996
Steel manufacture:	
Open hearth [1]	31
Electric furnace	2,680
Other furnaces	260
Total consumption	677,979
Ending stocks December 31	77,583
CONTAINING NOT MORE THAN 97 PERCENT CALCIUM FLUORIDE	
Glass	16,395
Enamel	4,332
Welding rod coatings [2]	11,658
Nonferrous metals	14,229
Iron foundry	32,158
Steel manufacture:	
Open hearth	108,659
Basic oxygen	307,125
Electric furnace	66,317
Other furnaces	1,386
Other uses [3]	3,176
Total consumption	565,435
Ending stocks December 31	245,538
ALL GRADES	
Hydrofluoric acid	659,524
Glass	24,184
Enamel	4,757
Welding rod coatings	11,658
Nonferrous metals	20,503
Iron foundry	33,154
Steel manufacture:	
Open hearth	108,690
Basic oxygen	307,125
Electric furnace	68,997
Other furnaces	1,646
Other uses [3]	3,176
Total consumption	1,243,414
Ending stocks December 31	323,121

[1] Includes other uses containing more than 97 percent calcium fluoride.

[2] Includes welding rod coatings containing more than 97 percent calcium fluoride.

[3] Includes fluorspar used in the manufacture of ferroalloys.

FOREIGN TRADE

Fluorspar was imported by the United States in 1968 in greater volume than ever before, almost 1.1 million tons compared with 900,000 in 1967. Thus, of the total quantity of fluorspar of all grades that served the needs of U.S. industry in 1968, 4 tons out of 5 were of foreign origin, and of those 4, 3 originated in Mexico. Spain and Italy also were substantial suppliers. Exports of fluorspar, although much below the level of imports, constituted a significant item of foreign trade.

The rates of duty imposed by the United States on imported fluorspar, unchanged since January 1, 1963, were $2.10 per long ton (equivalent to $1.875 per short ton) for material containing more than 97 percent CaF_2 and $8.40 per long ton ($7.50 per short ton) for material not over that percentage.

WORLD REVIEW

A number of journal articles published in the United States and abroad contained information concerning the 1968 international fluorspar situation.[2]

Canada.—The manager of a large mine on Newfoundland's Burin Peninsula, an important producer of acid-grade fluorspar since 1941, reported difficulty in recruiting and keeping manpower. At one time an abnormal incidence of pulmonary disease among the miners was experienced at this operation, and apprehension on the part of prospective workers appears to persist even though no new occurrences of lung malignancy have been reported there since the installation of an improved ventilating system in 1960. In August 1968 a second mine was brought into production that will augment the fluorspar output of the Burin Peninsula by 25,000 tons annually.

Czechoslovakia.—Construction was nearly completed of a new flotation plant at Sobedruhy, northern Bohemia, that is expected to provide 50,000 tons of acid-grade fluorspar annually for the needs of domestic industry.

India.—At Ambadungar, Gujarat State, the nation's first fluorspar processing plant was nearly completed and was expected to be ready for operation early in 1969. The

---

[2] Chermette, Alexsis. Le Marche de Spath-Flour dans le Monde (Fluorspar Trade Around the World). Mines at Metallurgie (Paris), May-December 1968 (preprint), 14 pp.
Industrial Minerals (London). World Fluorspar Markets. No. 9, June 1968, pp. 15–26.
———. Mineraria Silius—Largest Producer of Acid-Grade Fluorspar in Italy and the EEC. No. 10, July 1968, pp. 21–22.
Montgomery, Gill. Fluorspar. Domestic and Foreign. Min. Eng., v. 21, No. 3, March 1969, pp. 63–66.
Wells, J. Robert. Fluorspar. Eng. & Min. Jour., v. 170, No. 3, March 1969, pp. 160–160B.

Table 4.—Fluorspar shipped from mines in the United States, by grade and use

Grade and use	1967 Quantity Short tons	1967 Quantity Percent of total	1967 Value Total (thousands)	1967 Value Average per ton	1968 Quantity Short tons	1968 Quantity Percent of total	1968 Value Total (thousands)	1968 Value Average per ton
Ground and flotation concentrates:								
Hydrofluoric acid	135,622	54.5	$6,684	$49.29	88,782	40.6	$4,460	$50.28
Glass	31,797	12.8	1,472	46.29	34,495	15.8	1,675	48.57
Ceramic and enamel	4,924	2.0	232	47.17	7,791	3.6	303	38.83
Nonferrous	3,831	1.5	178	46.59	3,234	1.5	158	48.87
Ferrous	68,879	27.6	3,140	45.58	79,578	36.4	3,763	47.29
Miscellaneous [1]	3,995	1.6	184	46.10	4,547	2.1	224	49.21
Total [2]	249,048	100.0	11,891	45.75	218,427	100.0	10,582	48.47
Fluxing gravel and foundry lumps:								
Nonferrous	17	------	1	49.00	------	------	------	------
Ferrous	38,093	81.8	1,133	29.74	31,927	93.9	1,054	33.01
Miscellaneous	8,485	18.2	139	16.40	2,057	6.1	20	9.76
Total [2]	46,595	100.0	1,273	27.32	33,984	100.0	1,074	31.60

[1] Includes exports.
[2] Data may not add to totals because of independent rounding.

Table 5.—Fluorspar (domestic and foreign) consumed in the United States, by States

(Short tons)

State	1967	1968
Alabama, Georgia, North Carolina	12,674	12,108
Arkansas, Kansas, Louisiana, Mississippi, Oklahoma	137,204	173,140
California	51,165	47,131
Arizona, Colorado, Utah	23,996	27,323
Connecticut	870	874
Delaware and New Jersey	99,380	101,414
Florida, Rhode Island, Virginia	1,431	1,898
Illinois	60,521	64,142
Indiana	43,145	42,802
Iowa, Minnesota, Nebraska [1], Wisconsin	3,020	1,817
Kentucky	64,390	66,442
Maryland	31,101	35,654
Massachusetts	403	W
Michigan	65,674	77,413
Missouri	2,715	2,148
New York and Vermont	31,340	38,409
Ohio	111,106	187,321
Oregon and Washington	1,655	1,674
Pennsylvania	89,252	105,134
Tennessee	2,385	1,939
Texas	215,326	254,393
West Virginia	42,405	50,238
Total	1,091,158	1,243,414

W Withheld to avoid disclosing individual company confidential data; included with Connecticut.
[1] 1967 only.

Table 6.—Stocks of fluorspar at mines or shipping points in the United States, by States, Dec. 31

(Short tons)

State	1967 Crude	1967 Finished	1968 Crude	1968 Finished
Illinois	98,031	16,797	58,722	5,939
Utah	------	------	150	150
Other States [1]	28,685	5,725	38,650	6,468
Total	126,716	22,522	97,522	12,557

[1] Includes Colorado, Kentucky, and Montana.

mill has a rated capacity to produce 40,000 tons per year of finished fluorspar concentrate from material mined at a nearby deposit that is estimated to contain approximately 12 million tons of 30-percent fluorite ore.

Mexico.—Asarco Mexicana S.A., an affiliate of American Smelting & Refining Co., completed a new flotation mill at Parral, Chihuahua, designed to recover 85,000 tons annually of acid-grade fluorspar from accumulated lead-zinc concentrator tailings, the largest plant yet built exclusively for that type of feed. Increased production of metallurgical-grade fluorspar in San Luís Potosí was facilitated by the completion there of a new three-compartment hoisting shaft at the Riolito mine of Minera Continental S.A. near Río Verde. Also in the Río Verde district, Mexican interests established a new company to launch an operation which, it is asserted, will soon

Table 7.—U.S. exports of fluorspar

Year	Short tons	Value (thousands)
1966	5,732	$301
1967	10,345	517
1968	12,614	496

rank among the world's largest producers of metallurgical-grade fluorspar.

South Africa, Republic of.—Transvaal Mining and Finance Co. Ltd., a major fluorspar producer, reported only limited success in an effort to concentrate fluorite from mines in the western Transvaal by flotation procedures found applicable to ore taken from the granite-associated vein deposits in the north. The western fluorspar occurs in dolomite and presents an essentially different processing problem.

In the central Transvaal, plans were announced for an investment of about $5 million to develop a mine and flotation mill to exploit fluorspar ore from a deposit in the Bushveld igneous formation north of Pretoria. The output of the proposed operation is expected to amount to 50,000 tons of acid-grade fluorspar annually.

Thailand.—Research and Resources Co., a joint enterprise of national and U.S. interests, retained Philip Bradley, chairman of the California State Mining & Geology Advisory Board, to initiate a program of modernization aimed at achieving at least a twofold expansion of the 3,000- to 5,000-ton-per-month output from its fluorspar operations in Petchaburi Province. Thailand's production of fluorspar from all mines in 1968 was estimated to be about 270,000 tons, only slightly less than the comparable figure for the United States.

TECHNOLOGY

Substantially more than half the fluorspar of commerce is consumed for chemical purposes, especially for the manufacture of hydrogen fluoride, from which elemental fluorine and a host of fluorine compounds are derived. One class of these compounds, the fluoropolymers, possess exceptional chemical and physical characteristics that enable them to perform satisfactorily in tasks for which most inorganic substances are useless and while exposed to conditions under which most other organic compounds would be destroyed. Polytetrafluoroethylene, for example, a versatile polymer widely known under a shorter trade name and currently being produced at the rate of some millions of pounds annually, serves in applications over a temperature range from the intense cold in the tank that holds the liquid-hydrogen fuel of a space rocket to the friction-heated wing surfaces of supersonic aircraft. Not only does this remarkable material maintain its size and shape under such extremes of temperature, it also keeps its electrical properties intact, while exhibiting at the same time a lower coefficient of friction than that of any other solid substance yet known to science. An informative account of the nature and present status of these fluorocarbon synthetics, together with some forecast of likely developments in their future was published in a journal article.[3]

Officials of Oesterreischische Stickstoffwerke A.G. stated that chemists of that Austrian chemical manufacturing firm have devised a process in which byproduct or waste fluosilicic acid from fertilizer production can be used for making aluminum fluoride—"cheaper and much purer" than by conventional methods—, assuredly an item of interest in the United States where the operations of aluminum smelters require the annual consumption of thousands of tons of aluminum fluoride, in large part produced expensively from imported fluorspar. That interest should be sharpened by the fact that the need for air-pollution control presents U.S. phosphate rock processors with an imperative disposal problem involving thousands of tons of waste-product fluorine ever year, mostly in the form of fluosilicic acid.[4]

---

[3] Gosnell, Rex B. Fluorine Means Unusual Polymers. Ind. Res., October 1968, pp. 79–83.

[4] Industrial Minerals (London). New Route to Fluorine. No. 5, February 1968, p. 24.

Table 8.—U.S. imports for consumption of fluorspar, by countries and customs district

Country and customs district	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
CONTAINING MORE THAN 97 PERCENT CALCIUM FLUORIDE				
Colombia: Laredo, Tex	229	$7	---------	---------
France: New York City	22	1	---------	---------
Germany, West: Detroit, Mich	---------	---------	9,574	$296
Italy:				
Cleveland, Ohio	---------	---------	5,040	166
Detroit, Mich	4,287	153	14,734	610
Galveston, Tex	11,297	363	22,786	717
New Orleans, La	22,793	731	28,402	922
Philadelphia, Pa	24,067	787	26,580	1,047
Total	62,444	2,034	97,542	3,462
Mexico:				
Baltimore, Md	333	11	---------	---------
El Paso, Tex	78,349	1,964	81,569	2,050
Galveston, Tex	354	11	---------	---------
Houston, Tex	176	4	206	5
Laredo, Tex	235,543	6,259	255,908	6,879
Los Angeles, Calif	177	4	---------	---------
New Orleans, La	42,368	1,287	35,812	1,308
New York City	261	8	---------	---------
Philadelphia, Pa	---------	---------	8,478	296
San Diego, Calif	282	9	---------	---------
Total	357,843	9,557	381,973	10,538
Spain:				
Cleveland, Ohio	26,255	969	12,682	483
Detroit, Mich	9,463	282	21,514	620
Galveston, Tex	26,591	857	---------	---------
New Orleans, La	---------	---------	4,586	147
New York City	3	7	2	4
Norfolk, Va	3,784	133	---------	---------
Philadelphia, Pa	86,330	3,514	94,759	3,927
Total	152,426	5,762	133,493	5,181
United Kingdom:				
Cleveland, Ohio	5,716	170	7,260	264
New Orleans, La	14,688	387	8,136	252
San Juan, Puerto Rico	299	17	155	7
Total	20,703	574	15,551	523
Grand total	593,667	17,935	638,133	20,000
CONTAINING NOT OVER 97 PERCENT CALCIUM FLUORIDE				
Canada:				
Buffalo, N.Y	3,552	$72	12,438	291
Detroit, Mich	60	2	---------	---------
Total	3,612	74	12,438	291
Greenland: Laredo, Tex	---------	---------	76	1
Japan: Detroit, Mich	27	1	---------	---------
Mexico:				
Baltimore, Md	18,603	387	38,924	1,002
Buffalo, N.Y	31,951	708	14,398	370
Cleveland, Ohio	26,525	658	27,589	751
Detroit, Mich	27,929	599	28,380	720
El Paso, Tex	77,857	1,557	69,257	1,385
Laredo, Tex	73,977	1,113	147,250	2,188
Los Angeles, Calif	---------	---------	676	14
Mobile, Ala	3,461	88	9,498	248
New Orleans, La	29,651	855	33,476	924
Norfolk, Va	1,054	21	---------	---------
Philadelphia, Pa	10,860	251	29,962	802
Total	301,868	6,237	399,410	8,404
South Africa, Republic of: Baltimore, Md	12,696	238	---------	---------
United Kingdom: San Juan, Puerto Rico	---------	---------	50	3
Grand total	318,203	6,550	411,974	8,699

Table 9.—World production of fluorspar, by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada [e]	96,000	112,000	79,000	94,000	98,000
Mexico	708,644	810,618	[r] 800,715	865,439	1,021,000
United States (shipments)	217,137	240,932	253,068	295,643	252,411
South America:					
Argentina	12,703	12,883	[r] 17,734	[p] 17,000	NA
Chile	NA	NA	237	502	NA
Europe:					
France (marketable)	215,119	215,573	237,476	269,000	NA
Germany:					
East [e]	77,000	88,000	88,000	88,000	88,000
West (marketable)	98,960	91,402	93,195	95,821	[e] 100,000
Italy	137,449	[r] 169,020	[r] 194,020	226,190	[e] 249,000
Spain (marketable)	164,995	243,248	[r] 247,000	268,000	282,000
United Kingdom [2]	114,200	128,700	[r] 164,600	156,700	159,800
U.S.S.R. [e]	330,000	385,000	385,000	420,000	420,000
Africa:					
Morocco	7,242	3,307	[e] 3,300	---------	---------
Rhodesia, Southern	77	165	165	165	165
South Africa, Republic of	66,431	72,517	90,266	105,058	119,667
Tunisia	---------	[e] 3,300	2,894	2,756	6,008
Asia:					
China, mainland [e]	220,000	240,000	280,000	280,000	280,000
India	429	607	1,178	1,778	1,305
Japan	21,078	18,205	15,472	16,871	17,335
Korea:					
North [e]	33,000	33,000	33,000	33,000	33,000
South	62,167	43,174	35,283	62,796	51,372
Mongolia [e]	63,000	83,000	[r] 55,000	55,000	66,000
Thailand	70,039	57,132	52,941	146,775	270,173
Turkey	1,436	1,187	1,659	[e] 1,600	2,209
Total [3]	2,717,106	3,052,970	3,131,203	3,502,094	NA

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Fluorspar is also produced in Australia, Brazil, and Bulgaria, but details are not available.

[2] Excludes recovery from lead and zinc mine dumps.

[3] Total is of listed figures only.

Table 10.—International fluorspar trade in 1967

(Short tons)

Producing country	Exports	Principal destinations
Bulgaria	[1] 5,803	East Europe 4,352; Yugoslavia 880; Japan 571.
China, mainland	[1] 176,473	Japan 142,519; West Europe 24,535; East Europe 9,419.
France	120,266	West Europe 117,266; East Europe 1,548; Asia 1,046.
Germany:		
East	[1] 23,276	East Europe 13,668; West Europe 9,608.
West	10,365	West Europe 9,507; East Europe 442.
Italy	94,002	United States 84,239; West Europe 6,045.
Japan	514	Asia 459; Australia 55.
Korea:		
North	[1] 12,248	Japan 6,131; East Europe 6,117.
South	53,113	Japan 50,919; Philippines 1,119.
Mexico	833,654	United States 697,877; Canada 135,612.
Mongolia	[1] 51,300	All to U.S.S.R.
South Africa, Republic of	99,277	Japan 61,293; U.S. 12,801; West Germany 9,840.
Spain	188,738	United States 149,887; West Europe 35,929; India 2,839.
Thailand [2]	138,618	Japan 132,217; India 5,055; Taiwan 606.
United States	10,344	Canada 6,593; India 3,382.

[1] From import detail of destination countries.

[2] Group category; fluorspar, feldspar, leucite, and nepheline syenite.

CRYOLITE

Natural cryolite, theoretically the sodium and aluminum fluoride double salt Na_3AlF_6, mined at Ivigtut near the southern tip of Greenland, was imported and processed in a plant at Natrona, Pa., by Pennsalt Chemicals Corp. Additional quantities of cryolite were produced synthetically from fluorspar or were salvaged from scrapped aluminum-smelter pot linings by Aluminum Company of America at Point Comfort, Tex., and by Kaiser Aluminum & Chemical Corp. at Chalmette, La., and at Spokane, Wash.

PRICES

Cryolite prices listed in the Oil, Paint and Drug Reporter, December 30, 1968, were as follows: Natural, industrial, in bags, at works, carlots, $15 per 100 pounds; less than carlots, $16.75 per 100 pounds. These prices were about 15 percent higher than the respective quotations for the previous year.

FOREIGN TRADE

The import figures compiled by the Bureau of the Census (table 11) do not distinguish between natural and synthetic cryolite, but it can be assumed that only the shipments from Greenland consisted of the natural mineral and that essentially all of the remainder was synthetic. It is noteworthy that Greenland supplied only 22 percent of the total U.S. cryolite imports in 1968, down from 55 percent in 1967, and nearly 80 percent in 1963. Data on exports of cryolite were not available.

Table 11.—U.S. imports for consumption of cryolite

Year and country	Short tons	Value (thousands)
1965	24,011	$2,009
1966	31,655	3,199
1967:		
Canada	2,689	453
France	7,558	1,449
Germany:		
East	679	115
West	1,486	303
Greenland [1]	19,953	1,032
Italy	3,954	766
Total	36,319	4,118
1968:		
Canada	3,128	573
Denmark	220	46
France	6,415	1,227
Germany, West	108	25
Greenland [1]	7,570	347
Italy	15,943	3,163
Japan	112	22
Spain	265	51
Switzerland	11	1
Total	33,772	5,455

[1] Crude natural cryolite.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 C—392-738/15

Gem Stones

By Benjamin Petkof[1]

Estimates of domestic gem stone production indicate that output has increased slightly from $2.4 million in 1967 to $2.5 million in 1968. The United States has no formal gem stone mining industry and the collection of gem materials rests firmly in the hands of individual collectors and rock hobbyists as a recreational activity.

DOMESTIC PRODUCTION

Thirty-eight States produced gem material during 1968. The following States were the major producers and supplied material valued in excess of $100,000: Oregon, California, Idaho, Texas, Arizona, Wyoming, Colorado, and Montana. These States supplied 72 percent of total production.

CONSUMPTION

Consumption of both rough and cut gem diamond exceeded 4.3 million carats valued at $475 million, an increase of 10 percent in quantity and 23 percent in value over that of 1967. The value of imported synthetic and imitation gem stones including imitation pearl reached $12.4 million, an increase of 20 percent over that of the previous year; natural and cultured pearls declined 24 percent from 1967.

Apparent consumption of gem stones (domestic production plus imports minus exports and reexports) increased 45 percent from $304 million in 1967 to $441 million in 1968.

PRICES

During the year, price ranges for cut and polished, unmounted gem diamond were 0.25 carat, $75 to $400; 0.50 carat, $200 to $800; 1 carat, $650 to $2,500; 2 carats, $1,500 to $9,000; 3 carats, $3,000 to $18,000.

FOREIGN TRADE

Exports of precious and semiprecious gem stone increased over 50 percent to a value of $99.2 million. Diamond, over one-half carat in weight, cut but unset made up the bulk of the exports.

Imports of gem material increased 22 percent in value over those of 1967 with gem diamond accounting for 88 percent of the total.

Emerald imports almost doubled, with India and Colombia supplying almost 60 percent of the receipts.

Ruby and sapphire imports increased 61 percent and were received from 27 countries with Ceylon, Burma, and India furnishing 68 percent of the total.

Imports of natural and cultured pearl declined with India and Japan supplying the major portions of natural and cultured material, respectively.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—U.S. imports for consumption of precious and semiprecious gem stones

(Thousand carats and thousand dollars)

Stones	1967		1968	
	Quantity	Value	Quantity	Value
Diamonds:				
Rough or uncut ----- carats	2,506	$212,902	2,514	$252,653
Cut but unset ----- do	1,455	174,570	1,834	222,478
Emeralds: Cut but unset ----- do	242	5,518	365	10,644
Rubies and sapphires: Cut but unset	NA	5,685	NA	9,175
Marcasites	NA	3	NA	1
Pearls:				
Natural	NA	576	NA	525
Cultured	NA	17,140	NA	12,865
Imitation	NA	374	NA	403
Other precious and semiprecious stones:				
Rough and uncut	NA	4,900	NA	5,062
Cut but unset	NA	[r] 7,745	NA	11,038
Other, n.s.p.f	NA	270	NA	374
Synthetic:				
Cut but unset ----- number	3,042	1,332	5,085	2,404
Other	NA	104	NA	166
Imitation gem stones	NA	[r] 8,476	NA	9,405
Total	NA	439,645	NA	537,193

[r] Revised. NA Not available.

Table 2.—U.S. imports for consumption of diamond (exclusive of industrial diamond), by countries

(Thousand carats and thousand dollars)

Country	1966				1967				1968			
	Rough or uncut		Cut but unset		Rough or uncut		Cut but unset		Rough or uncut		Cut but unset	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Belgium-Luxembourg	72	$9,520	787	$94,353	47	$6,111	775	$96,676	46	$7,455	954	$119,396
Brazil	4	425	--------	--------	21	1,009	2	169	10	594	(1)	8
Canada	10	1,663	(1)	16	5	847	(1)	64	9	1,256	5	205
Central African Republic	187	9,835	--------	--------	183	9,002	--------	--------	218	11,818	1	61
France	3	211	18	1,902	1	101	17	2,085	22	1,004	22	2,514
Germany, West	(1)	1	17	1,441	2	227	11	1,039	(1)	2	5	556
Ghana	20	464	--------	--------	5	68	--------	--------	--------	--------	(1)	46
Guyana	25	995	(1)	8	31	1,370	--------	--------	14	830	(1)	5
India	--------	--------	8	720	--------	--------	14	1,239	--------	--------	30	2,714
Ireland	56	2,248	2	101	132	571	3	240	--------	--------	3	305
Israel	36	3,096	525	51,446	46	4,079	533	55,033	50	5,245	666	70,217
Japan	(1)	6	1	78	(1)	14	2	150	(1)	52	1	100
Liberia	16	1,831	--------	--------	26	3,946	--------	--------	7	1,898	--------	--------
Netherlands	49	8,825	21	3,013	39	8,566	14	2,065	46	9,953	19	3,073
Sierra Leone	161	7,705	(1)	53	180	5,921	3	307	61	1,892	9	1,310
South Africa, Republic of	121	13,023	28	7,001	333	39,852	32	7,766	434	46,380	35	9,076
Switzerland	69	8,504	1	422	7	1,524	(1)	174	20	2,039	4	785
U.S.S.R.	--------	--------	29	3,391	(1)	17	39	5,918	--------	--------	63	9,588
United Kingdom	1,106	131,809	10	1,354	1,339	122,000	10	1,395	1,439	152,881	17	2,239
Venezuela	66	2,525	--------	--------	64	2,347	--------	--------	95	3,468	--------	--------
Western Africa, n.e.c	21	3,446	--------	--------	35	4,260	(1)	6	36	5,614	(1)	5
Other countries	10	1,907	5	438	10	1,070	(1)	244	7	272	(1)	275
Total	2,032	208,039	1,452	165,737	2,506	212,902	1,455	174,570	2,514	252,653	1,834	222,478

[1] Less than ½ unit.

WORLD REVIEW

Canada.—Kimberlite dikes were discovered underground at the Upper Canada Mines, Limited, by the Geological Survey of Canada. Upper Canada and neighboring Queenston Gold Mines Limited, entered into an exploration agreement with Canadian Rock Company Limited, a wholly owned subsidiary of De Beers Consolidated Mines Ltd. of South Africa. During the latter part of the year an announcement was made that work progress had not been encouraging.

The Kimberlite Mining Corporation Limited began a drilling and geophysical program in the Coral Rapids area of northern Ontario. Reportedly a 250-foot width of kimberlite material was found during drilling.[2]

Ceylon.—Export duties on precious and semiprecious stones were abolished effective November 16, 1968. The abolition of duties was expected to provide incentive for gem exporters to accept foreign exchange controls.[3]

Colombia.—The Government has established a group called the Empresa Colombiana de Esmeraldas to develop and administer deposits of emeralds and other precious stones in the national reserve region of Colombia. The directorate of this organization will consist of the Minister of Mines and four other members appointed by the Government. The issuance of permits to others for the purposes of exploration and development of emerald deposits has been suspended.[4]

---

[2] Canadian Mining Journal. Diamonds. V. 90, No. 2, February 1969, p. 124.

[3] U.S. Embassy, Ceylon. State Department Airgram A-544, Nov. 27, 1968, p. 1.

[4] Mining Journal (London). Columbia Emerald Exploitation. V. 271, No. 6942, Sept. 6, 1968, p. 168.

Table 3.—World production of gem diamond, by countries

(Thousand carats)

Country	1964	1965	1966	1967	1968 [p]
Africa:					
Angola	[r] 874	[r] 887	[r] 968	983	1,316
Central African Republic	221	268	270	• 260	• 305
Congo (Kinshasa)	295	14	[r] 12	1	551
Congo (Brazzaville) • [1] [2]	316	318	300	NA	NA
Ghana	378	25	282	254	• 245
Guinea •	21	21	21	NA	NA
Ivory Coast	120	119	110	• 105	• 110
Liberia [1]	298	277	343	362	537
Sierra Leone	585	658	629	560	• 560
South-West Africa	1,387	1,491	1,583	[r] [3] 1,531	[3] 1,552
Tanzania	338	• 414	• 474	864	356
South Africa, Republic of: •					
Premier	556	610	625	594	608
De Beers Group [4]	928	985	1,429	2,128	2,307
Other pipe mines	18	123	181	334	484
Alluvial	288	230	300		
Total, South Africa, Republic of	1,790	1,948	2,485	[r] 3,056	3,399
Total Africa	[r] 6,623	[r] 6,440	[r] 7,477	[r] 7,976	8,931
Other Areas:					
Brazil •	175	175	150	160	160
Guyana	60	45	37	41	28
India	2	[r] 4	2	5	7
Indonesia	14	[r] 14	[r] 14	14	14
U.S.S.R. •	800	1,000	1,200	1,400	1,400
Venezuela	57	52	42	38	60
Total [5]	[r] 7,731	[r] 7,730	[r] 8,922	[r] 9,634	10,600

• Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Exports, fiscal year ending August 31.

[2] Probable origin Congo (Kinshasa).

[3] Output of Consolidated Diamond Mines of South-West Africa Ltd.

[4] Includes some alluvial from De Beers properties.

[5] Totals are of listed figures only.

Guyana.—The diamond production potential was discussed and reviewed in a recent paper. Production was primarily industrial with a small quantity of gem grade and was from alleuvial deposits.[5]

India.—The Geological Survey of India has begun work to determine the feasibility of commercially extracting diamond from the pipe rock, conglomerates, and river gravels in Andhra Pradesh.[6]

Sierra Leone.—In November 1968, a mining agreement was reached between the Diamond Corporation West Africa Ltd. and the Sierra Leone Government wherein the corporation would be the sole marketer and exporter of diamond produced under the Alleuvial Diamond Mining Scheme. The terms of the agreement require that the corporation pay an annual fee to the Government for these rights and forego the service fee paid for its operation of the Government Diamond Office. The agreement became effective at the beginning of 1969.[7]

Thailand.—Imports and exports of precious and semiprecious stones for 1967 were published.[8]

TECHNOLOGY

Several papers were published concerning the development of kimberlite deposits. These papers presented theories and supporting data on the occurrence of diamond and other materials in kimberlite.[9]

The refractive index of type I diamond has been shown to vary indirectly with pressure. A direct measurement technique, with the application of hydrostatic pressure, was used to make direct measurements to a pressure of 7 kilobars.[10]

---

[5] Norwood, V. G. C. Guyana—an Expanding Source of Industrial Diamonds. Min. Mag., v. 118, No. 3, March 1968, pp. 169–171.

[6] Journal of Mines, Metals & Fuels. Exploration for Diamonds in Andhra Pradesh. V. 14, No. 8, August 1968, p. 285.

[7] Bureau of Mines. Mineral Trade Notes. Diamond (Sierra Leone). V. 66, No. 3, March 1969, p. 7.

[8] Bureau of Mines. Mineral Trade Notes. Gem stones. V. 65, No. 12, December 1968, pp. 18–19.

[9] Crockett, Richard N., and Robert Mason. Foci of Mantle Disturbance in Southern Africa and Their Economic Significance. Econ. Geol., v. 63, No. 5, August 1968, p. 532–540.

Dawson, J. B. Recent Researches on Kimberlite and Diamond Geology. Econ. Geol., v. 63, No. 5, August 1968, p. 504–511.

Kennedy, George C., and Bert E. Nordlie. The Genesis of Diamond Deposits (Abstract). Econ. Geol., v. 63, No. 5, August 1968, p. 495–503.

[10] Schmidt, E. D. D., J. L. Kirk, and K. Vedam. Variation of the Refractive Index of Diamond With Hydrostatic Pressure to 7 Kilobars. Am. Miner., v. 53, Nos. 7–8, July–August 1968, pp. 1,404–1,406.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/6

Gold

By J. Patrick Ryan [1]

The most important event affecting gold producers and consumers in 1968 was the termination of gold sales in the London market by the central banks of the seven-nation International Gold Pool and the establishment of a two-tier price system—a fixed price of $35 per ounce for official monetary transactions and a floating market price for private transactions. This action became necessary to halt the heavy outflow of gold from official reserves to meet accelerated private demand stemming from monetary and political uncertainties.

The United States by enacting legislation removing the 25-percent gold backing of Federal Reserve Notes effectively severed the last remaining link between the Nation's gold reserve and the amount of currency that can be issued.

Domestic mine output of gold was slightly less than in 1967 reflecting continuation of the copper strike, which cut off most of the byproduct gold production in the first quarter. Smaller output by the two major gold mines also contributed to the overall decline.

World gold production increased slightly as gains in South Africa, Philippines, and the U.S.S.R. more than offset losses in the United States, Canada and most other countries. Gold output in the Republic of South Africa reached a new high.

Gold reserves of non-Communist central banks and Governments declined for the third consecutive year indicating that private demand again exceeded new production. The continued heavy outflow of gold reduced the U.S. gold stock to the lowest level since September 1936.

U.S. industrial consumption of gold continued to expand reaching a record high for the seventh consecutive year.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Salient gold statistics

	1964	1965	1966	1967	1968
United States:					
Mine production...thousand troy ounces..	1,456	1,705	1,803	1,584	1,478
Value...thousands..	$50,971	$59,682	$63,119	$55,447	[1] $58,038
Ore (dry and siliceous) produced:					
Gold ore...thousand short tons..	2,631	3,113	3,447	3,076	2,780
Gold-silver ore...do....	224	206	248	157	199
Silver ore...do....	542	752	669	617	655
Percentage derived from—					
Dry and siliceous ores...	54	54	58	69	63
Base-metal ores...	37	40	37	27	34
Placers...	9	6	5	4	3
Refinery production [2] thousand troy ounces..	1,469	1,675	1,802	1,526	1,539
Exports...do....	12,078	36,717	13,067	28,720	23,962
Imports, general...do....	1,169	2,905	1,200	980	5,944
Stocks Dec. 31: Monetary [3]...millions..	$15,471	$13,806	$13,235	$12,065	$10,892
Industrial...thousand troy ounces..	2,329	2,656	2,784	3,086	3,617
Consumption in industry and the arts thousand troy ounces..	4,203	5,276	6,062	6,294	6,604
Price:...average per troy ounce..	[4] $35.00	[4] $35.00	[4] $35.00	[4] $35.00	[1] $39.26
World:					
Production...thousand troy ounces..	44,841	46,225	46,580	45,708	46,168
Official reserves [5]...millions..	$43,015	$43,230	$43,185	$41,600	$40,905

[1] Average U.S. Treasury price Jan. 2–Mar. 15, 1968, and Engelhard selling quotations Mar. 20–Dec. 31, 1968.

[2] From domestic ores—U.S. Bureau of the Mint.

[3] Includes gold in Exchange Stabilization Fund.

[4] Price under authority of Gold Reserve Act of Jan. 31, 1934.

[5] Held by free world central banks and governments.

Legislation and Government Programs.—Public Law 90–269 enacted in March removed the requirement that Federal Reserve Notes and other U.S. currency have as a reserve backing 25 percent of their value in gold. The new law freed approximately $10.53 million in gold for use in the international monetary system.

Legislation ratifying an amendment to the International Monetary Fund (IMF) Articles of Agreement authorizing U.S. participation in the Special Drawing Rights (S.D.R.) plan was enacted in June. The new law (Public Law 90–349) known as the Special Drawing Rights Act, authorized the Secretary of the Treasury to issue S.D.R.'s for financing exchange stabilization operations. The S.D.R.'s are designed essentially to supplement gold in international monetary transactions.

In a step to conserve remaining gold reserves, the United States and other members of the International Gold Pool decided on March 17 to restrict sales of gold from monetary stocks to official use only and no longer to supply gold to the London or any other gold markets, thus establishing a "two-tier" price system—$35 per ounce for intergovernment transactions and a floating open-market price for private account based on supply and demand. At the same time the U.S. Treasury terminated the purchase of gold from domestic producers and its sale to domestic consumers.

The Bureau of Mines and U.S. Geological Survey continued their investigations under the Interior Department's Heavy Metals Program established in 1966. The program objective is to stimulate domestic production of gold and other metals in short supply by developing improved extractive technology needed to economically exploit known large gold resources of submarginal grade, and by identifying areas geologically favorable for discovering new ore deposits, using advanced methods of search and analysis.

The Bureau of Mines revised its 1964 estimate of the Nation's gold resources and potential production to include the results of its exploration and research investigations under the Heavy Metals Program. The study disclosed gold resources totaling 237 million ounces potentially producible at cost levels up to $130 per ounce of which about 37 million ounces were producible at a price near $42 per ounce quoted at yearend. The Bureau's Heavy Metals investigations also included an analysis of the potential production of gold from secondary sources, particularly electronic scrap, and the development of improved methods of recovering gold from such material.

Nine contracts for gold or gold-silver exploration aggregating $233,340 were executed during the year under the financial assistance program administered by the Office of Minerals Exploration, U.S. Geological Survey. The Government share of the exploration cost was $175,005. The following project contracts were active or in force at yearend:

Operator	County and State	Total cost
Continental Quicksilver	Owyhee, Idaho	$61,360
Golden State Mining Co	Sierra, Calif	42,100
Dickey Exploration Co	Sierra, Calif	81,300
Louie Clark, Et al	Wilkes, Ga	22,500
Frank R. Ramsey	Baker, Oreg	34,400
J. P. Fuilham and A. F. Grant	Mariposa, Calif	12,000
R.J. Kirkpatrick	Plumas, Calif	23,000
Dexter C. Mayne	Riverside, Calif	4,000
Floyd G. Robinson	Shasta, Calif	50,000
Geomineral Corp	San Bernardino, Calif	20,000
High Sierra Mining Co	Sierra Calif	46,900
M&M Buchanan Gold Mining & Milling Corp	Tuolumne, Calif	12,200
Claude Lovestedt	Churchill, Nev	37,640
W. S. McGilvray & Morgan	San Bernardino, Calif	27,600
Total		$475,040

DOMESTIC PRODUCTION

In 1968, mine production of recoverable gold in the United States declined for the second consecutive year owing to the loss of byproduct output at copper smelters resulting from a strike which extended through the first quarter. Output dropped nearly 7 percent in the year to 1.48 million ounces, the lowest production since 1964; but, because of an increase in the market price of gold, value of output was nearly 5 percent more than in 1967. Production losses in Nevada and South Dakota were partly offset by a gain in gold output in Utah. These three States accounted for more than three-fourths of the total production. Two gold mines, Homestake and Carlin, contributed about 60 percent of the total U.S. gold production in 1968.

Yuba Consolidated Gold Fields closed down its last dredge operating on the Yuba River in October. The closing of this last major source of gold in California ended an industry which began 120 years ago.

Homestake Mining Co. reported[2] that 1.9 million tons of ore was treated in 1968 at its Homestake mine at Lead, S. Dak., from which 592,333 ounces of gold and 136,916 ounces of silver valued at $22.1 million was recovered, compared with $21.2 million in 1967.

Although the total quantity of gold produced decreased slightly, recovered value per ton was $12.23 compared with $11.18 in 1967. Metallurgical recovery was 95.2 percent. The average price received for gold sold to licensed customers from March 17, when the U.S. Treasury ceased buying gold from domestic producers, through December 31, 1968 was $40.19 per ounce. Measured ore reserves at yearend were 12.0 million tons averaging 0.319 ounce per ton a net decrease of 1.3 million tons during the year. In addition, 1.5 million tons of indicated ore averaging 0.40 ounce per ton was reported.

The Carlin Gold Mining Co. reported that gold production at its Carlin mine dropped nearly 17 percent to 280,000 ounces owing to a decline in the grade of ore milled. About 777,000 tons of ore averaging 0.385 ounce per ton were milled compared with 759,000 tons averaging 0.476 ounce per ton in 1967. Ore reserves at yearend were 6.4 million tons compared with 7.3 million tons at the end of 1967. The company indicated that an additional 500,000 tons of refractory carbonaceous ore might be treated if pilot plant tests of a process for treating such ore developed by the Bureau of Mines proved economically feasible. The company contracted to sell its impure bullion to American Metal Climax, Inc. (AMAX) for refining to commercial grade and sale to industrial users.[3]

At the Mayflower mine in the Park City district, Utah operated by Hecla Mining Co., gold output declined 9 percent to about 59,000 ounces. The mine treated 122,357 tons of ore averaging 0.53 ounce of gold per ton, 4.85 ounces of silver per ton, 3.96 percent lead, 3.22 percent zinc, and 0.88 percent copper. Estimated ore reserves at yearend totaled 309,000 tons compared with 331,000 at the beginning of the year.[4]

American Exploration & Mining Co. completed mine development, design, and construction of a 1,700 ton-per-day mill at its Cortez property and began tuneup operations prior to the scheduled start of full-scale operations early in 1969.

The 25 leading gold producers contributing 97 percent of the total domestic gold output comprised 4 lode gold mines, 3 placers mines, 13 copper mines, 2 copper-lead-zinc mines, 2 lead-zinc mines, and one iron mine.

Approximately 3,100 persons were employed in the gold mining industry in 1968.

---

[2] Homestake Mining Co. 91st Annual Report. Dec. 31, 1968, p. 6.

[3] Newmont Mining Corp. Annual Report. 1968, p. 8.

[4] Hecla Mining Co. Seventy-First Annual Report. Dec. 31, 1968, pp. 9, 13.

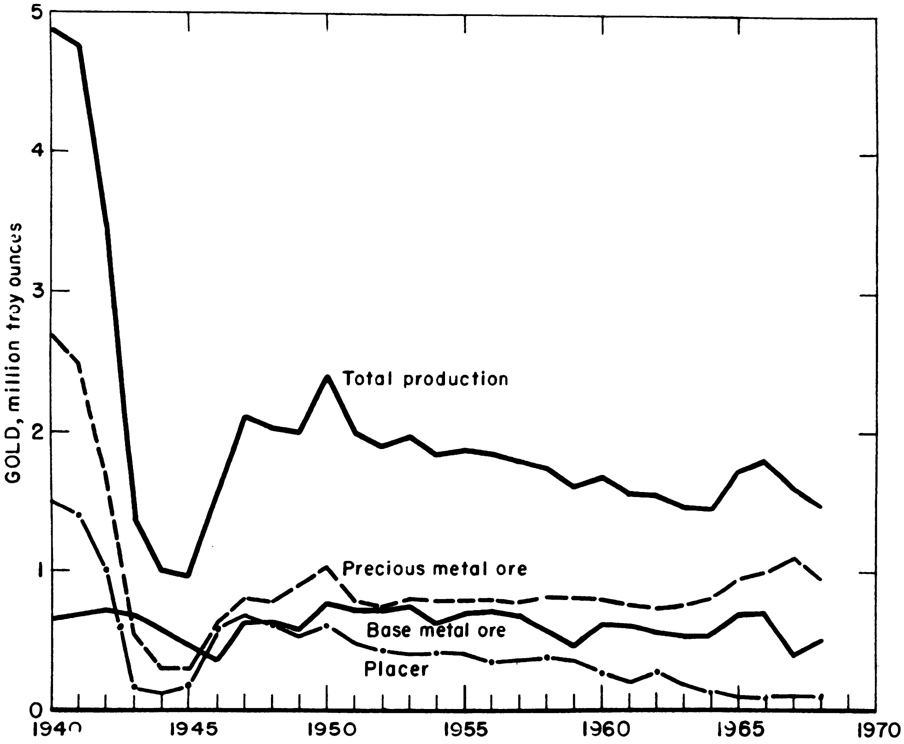

Figure 1.—Gold production in the United States.

CONSUMPTION AND USES

Domestic consumption of gold as indicated by sales to fabricators of industrial and artistic products increased nearly 5 percent to 6.6 million ounces, the seventh consecutive annual gain and a record high.

Data compiled by the Office of Domestic Gold and Silver Operations, U.S. Department of the Treasury, indicated that about 70 percent of the gold purchased by industrial consumers was used in fabricating jewelry and decorative products and in dental materials; the remainder was used chiefly in electrical and electronic components and other industrial products including space and defense equipment.

Apparent annual domestic consumption of gold in industry and the arts increased about 80 percent since 1963 indicating a compounded annual growth rate over the 5-year period 1963–68 of nearly 13 percent. Over this period total consumption was about 3.5 times domestic mine production.

Almost all gold used was in the form of metal or alloys. Karat gold, usually an alloy of gold and copper, forms the basis of high quality jewelry. Substantial quantities of gold also were consumed as electroplate in jewelry and decorative articles, and in electronic components in a wide variety of industrial products. Gold solders were used extensively in electronic devices and in dentistry.

Liquid bright gold essentially an organo-gold complex containing some sulfur and a trace of rhodium, was used largely for decorative coatings on glass and ceramics and to a lesser extent in industrial and structural applications. Conductive gold pastes were used in microelectronic components to interconnect semiconductor active devices.

Substantial quantities of gold brazing alloys were used in the aircraft industry and lesser amounts were consumed in the aerospace industry for thermal control surfaces, solid film lubrication surfaces for sliding electrical contacts, and meteorite detection.

In the electrical industry gold was used in printed circuitry, connectors, semiconductor parts, low-current contacts, vacuum tubes, subminiature and microminiature circuits for computers, and other sophisticated electronic installations. The growing application of gold in alloys, clad metals, or electroplate in communications and other electronic components, and in aerospace equipment, is based on such properties as high electrical conductivity, high heat and light reflectivity, superior malleability, and corrosion resistance. In most of its industrial applications, especially where functional reliability is paramount, there is no satisfactory substitute for gold, notwithstanding its relatively high price.

Gold-plated carbon steel was used in miniature piston actuators developed by U.S. Time Corp. to puncture metal diaphragms to release high-pressure gas in aerospace systems. The devices are explosive-actuated.

A gold-tin eutectic soldering paste developed by Alloys Unlimited, Inc., may reduce the cost involved in handling foil preforms in the semiconductor industry. It can be applied by dotting, banding or screen-printing.

Goodyear Aerospace Corp. used thin transparent gold coatings in a new process for making heated acrylic windows and windshields that will keep them free from ice and fog. Gold was employed because it is one of the best conductors of electricity and because its atomic structure renders it transparent in the thin state. The gold gives off enough heat when an electric current is passed through the thin film to keep the exterior surface above the freezing point of water even though the outside temperature is 65° F below zero. Goodyear used the process to produce heated windows for the Boeing 747 aircraft.

A neutral gold-plating process developed by Sel-Rex Corp. was used to provide dense uniform deposits to protect special test electrodes on the Delta launching vehicle from oxidation and electrochemical disturbances. The instrument packages on which the electrodes function are used to measure electrification both inside and outside the rocket.

STOCKS

Monetary.—The total U.S. gold stock, including gold in the Exchange Stabilization Fund, fell $1,173 million to $10,892 million at yearend, the lowest level since September 1936. The heavy outflow of gold occurred in the first 5 months and resulted largely from private speculative demand following devaluation of the pound Sterling and to a lesser extent to settlement of international trade balances. The 1968 gold loss was about the same as in 1967 and was equivalent to about 33.5 million ounces. The U.S. balance-of-payments position to which gold losses are closely related, measured on a liquidity basis, showed a surplus of $158 million owing essentially to a sharp rise in the inflow of foreign capital, compared with a deficit of $3,571 million in 1967. The U.S. gold tranche position in the I.M.F. which represents the amount that the United States could draw in foreign currencies, was $1,290 million at yearend.

Gold reserves of non-Communist central banks and governments and international banking institutions at yearend were estimated at $40,905 million compared with $41,600 million at yearend 1967. This was the third consecutive decline in official reserves in recent years, indicating that gold was supplied from monetary reserves in addition to new production to meet private demand. Accelerated private demand which reached a peak in March led to the termination of gold sales to private interests by the seven countries comprising the International Gold Pool.

Recognizing the inadequacy of new gold production and reserves to provide needed liquidity in international trade and balance-of-payments transactions, the IMF proposed the creation of Special Drawing Rights (S.D.R.'s) to supplement gold in international transactions. The adoption of the S.D.R. plan required approval of the majority of I.M.F. member countries.

The U.S. gold reserve of $10,892 million represented about 27 percent of the total official gold reserve of non-Communist countries, 2 percent less than that of a year ago. Gold reserves of other principal non-Communist countries at yearend in million dollars, were as follows: West Germany, 4,539; France, 3,877; Switzerland, 2,624; Italy, 2,923; Netherlands, 1,697; Republic of South Africa, 1,243; Belgium, 1,524; United Kingdom, 1,474 and Canada, 863. The International Monetary Fund's gold reserve was 2,288 million.[5]

U.S. short-term liabilities to foreign central banks and other foreign interests payable in dollars, reported by banks in the United States, increased $863 million to $31,158 million. These liabilities are potentially convertible to gold. More than one-half of the total liabilities were payable to West European countries.[6]

Industrial.—The quantity of gold held in inventories of domestic refiners and fabricators increased 531,000 ounces to 3,617,000 ounces at yearend, according to

---

[5] Federal Reserve Bulletin. V. 55, No. 6, June 1968, pp. A–70 to A–87.
[6] Work cited in footnote 5.

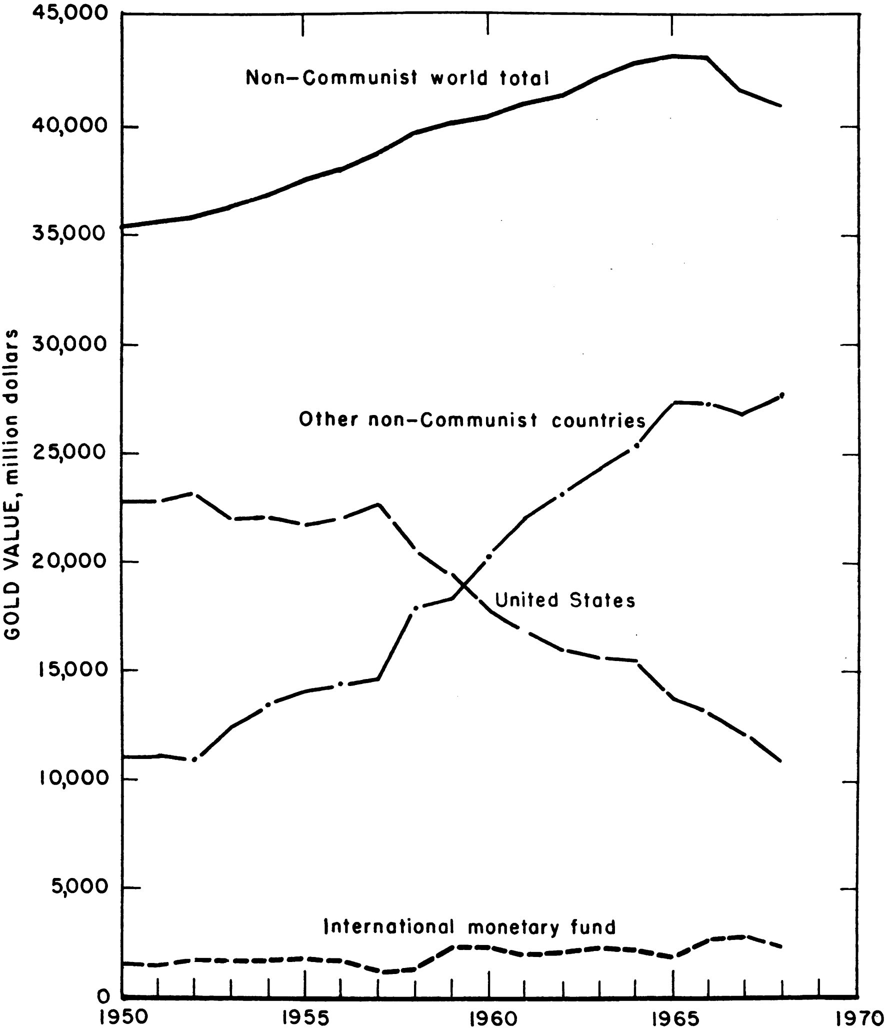

Figure 2.—Gold reserves of free world central banks and Governments.

the Office of Domestic Gold & Silver Operations, U.S. Department of the Treasury. In the 5-year period industrial inventories of gold increased 70 percent.

PRICES

The U.S. buying and selling price of gold remained unchanged at $35 per ounce until March 17, after which all purchases and sales for private accounts were terminated. This action was prompted by the heavy outflow of gold from official reserves stemming from monetary uncertainties following devaluation of the British pound and the political crisis in France. In a step to conserve remaining reserves, the United States and other members of the International Gold Pool agreed to restrict sales from monetary stocks to official use only and no longer to supply gold to the London or any other market, thus establishing a "two-tier" price system —$35 per ounce for intergovernment transactions and a floating open-market price for private account based on supply and demand.

When the two-tier market was established on March 17, the U.S. Government asked Engelhard Minerals & Chemical Corp. to quote a daily price. The firm initiated a buying quotation—the lowest price at which it could obtain sufficient gold of 99.95 percent purity to meet its requirements. A selling quotation 60 cents above the buying price, later reduced to 40 cents was also established. The establishment of a market essentially free of government influence resulted in price levels 15 to 20 percent above the official price. The average weekly free-market gold price (buying) quoted by Engelhard fluctuated in a range between $37.55 and $42.81 an ounce and at yearend was $42.30. The average calculated price for the full year was $39.26.

On the London market the final setting price based on the U.S. official price of gold generally ranged between $35.15 and $35.21 an ounce until the market closed on March 15. After the market reopened on April 1st the average weekly price of gold fluctuated between $37.31 in the first week of April to a high of $41.88 in May, closing the year at $41.60.

The price of gold bars ranged considerably higher in other foreign gold markets than in London, reflecting local political conditions and unofficial exchange rates. Prices at yearend were $42.50 per ounce at Beirut, $43.25 at Paris, $44.00 at Hong Kong, and $57.60 at Bombay. Market prices were affected by the uncertainties created when the Republic of South Africa temporarily withdrew from the gold market.

Premiums on gold coins over their gold content generally declined following establishment of the open-market price, except for the U.S. 20-dollar double eagles, on which the premium increased 2½ percent to 50¼ percent at yearend and the 20-franc Napoleons which closed at a premium of 62¼ percent, about the same as the beginning of the year. Premiums on other coins quoted by London bullion dealers at yearend in percent, were: Sovereigns (Queen Elizabeth) 11¼; Italian 20-lire, 55¾; Belgian 20-franc, 55¾; Swiss 20-franc, 58¼; and German 20-mark, 56¾.

The relationship of gold to the international monetary system and the need for maintaining the fixed $35 per ounce official price and the convertibility of the dollar into gold at that price were reemphasized during 1968 by Treasury and other Government officials. An official U.S. pronouncement on gold policy was made by Treasury Secretary Fowler on Sept. 24, 1968, as follows:

> . . . I would like to outline the central points underlying the policies of the United States on gold.
>
> First, the U.S. believes that gold has, and will continue to have, an important role in the system. Existing gold reserves are about $40 billion. This is more than half of total international reserves. The loss of these monetary reserves or a substantial diminution in their value as monetary reserves would be undesirable. Their relative proportion in world reserves will dimish over time, but they will continue to be a key element in international liquidity and in the operation of the international monetary system.
>
> Second, the U.S. believes that the maintenance of the existing official price of gold for monetary purposes and the convertibility of the dollar into gold at that price is the back-

bone of the monetary system; that to increase or decrease the official price of gold would be a highly destabilizing factor; that any change in the official price of gold would result in gross inequities and would needlessly endanger the international economic cooperation built up over the post war period.

Third, the U.S. believes we can no longer rely on gold production as a source of future additions to international liquidity. The Special Drawing Rights facility under the IMF is designed to meet this need.

Fourth, the U.S. believes that neither gold, nor gold markets, nor gold speculators should be permitted to unsettle and interfere with international economic stability. Nor should the international monetary system—or the world economy—be placed at the mercy of arbitrary forces that would result from sole or undue reliance on gold for monetary reserves.

A key premise of both the Washington Communique establishing the two-tier gold system and the adoption of the Special Drawing Right proposal at Stockholm was that the monetary price of gold would remain unchanged. This premise, abundantly evident, has still apparently not been understood or accepted by some.

With respect to the use of gold and S.D.R.'s in the international monetary system Managing Director Schweitzer stated at the annual meeting of the International Monetary Fund in September:

> While special drawing rights will, I expect, eventually become a major component of international reserves, it is important at this stage to do nothing to undermine, and to do whatever is possible to strenghten, the traditional reserve components. The new facility is intended, when the need arises, to supplement, not to supplant, gold and foreign exchange. This is no more than common sense. Gold is a traditional means of international settlement and a point of reference for the values of national currencies. The value of special drawing rights is guaranteed in terms of a weight of gold. More than one half of all monetary reserves consists of gold, and it continues to be the basic element in the world monetary system.

FOREIGN TRADE

Heavy shipments of gold abroad from the U.S. Monetary Stock to meet private demand, and balance-of-payments transfers in March and June resulted in a net export trade in 1968, the eighth consecutive year that exports exceeded imports. Net exports totaled 18.0 million ounces compared with 27.8 million ounces in 1967. About 96 percent of the total gold exported was shipped to the United Kingdom and nearly all of the remainder went to Singapore, Syrian Arab Republic, and Belgium-Luxembourg. Of the total imports of gold, Canada supplied 60 percent; nearly all of the remainder came from 21 other countries.

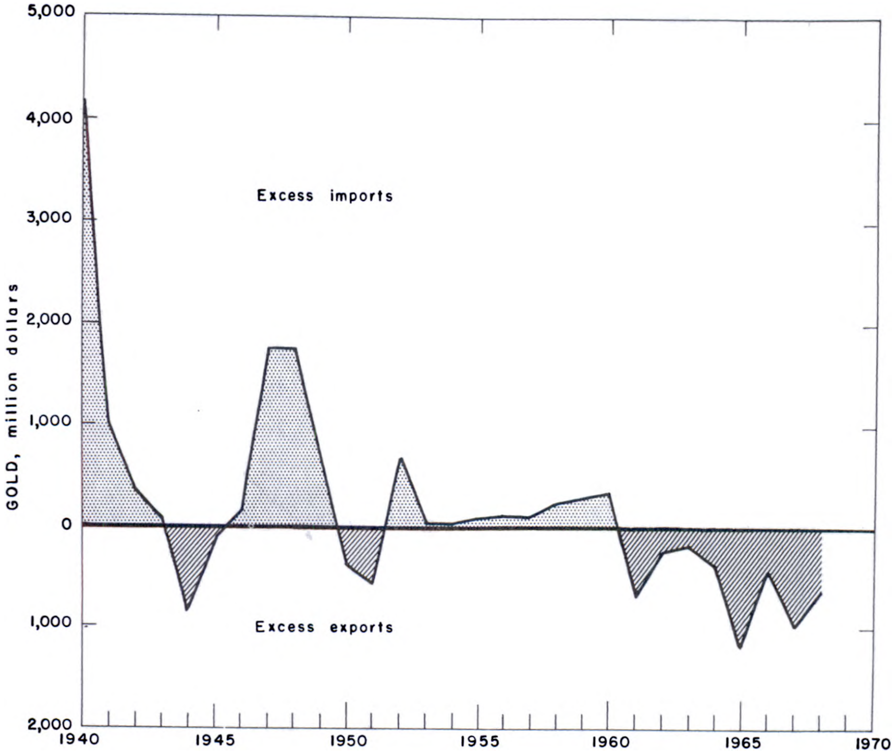

Figure 3.—Net exports or imports of gold.

WORLD REVIEW

World production of gold increased about 2 percent in 1968 to 46.2 million ounces, valued at $1,813 million. Production gains in the Republic of South Africa, the Philippines, and the U.S.S.R. more than offset declines in the United States, Canada, Ghana, Australia, and most other foreign countries.

Non-Communist consumption of gold in industry and the arts continued to grow and is estimated to have reached a level near 22 million ounces in 1968, about 48 percent of production.

Gold reserves of central banks and governments, excluding Communist-bloc countries, declined for the third successive year but the overall loss in 1968 of $695 million was less than one-half that in 1967. Official monetary reserves dropped sharply in the first quarter but after market sales were terminated by the Gold-Pool countries, reserves increased to about $40,905 million at yearend.

Canada.—Although gold production declined for the eighth consecutive year in 1968, Canada continued to rank as the third largest producing country. Output dropped to 2.75 million ounces, valued at nearly $113 million, about 10 percent less than in 1967. The average price per ounce paid the Canadian mint for newly mined gold was $37.71, about the same as in the preceding 3 years.

Five lode gold mines with an estimated annual production of more than 200,000 ounces of gold closed in 1968 as minable ore reserves were depleted. Two lode gold mines commenced production in 1968. Thirty-five lode mines were operating at yearend. All but five of these mines received financial assistance under the pro-

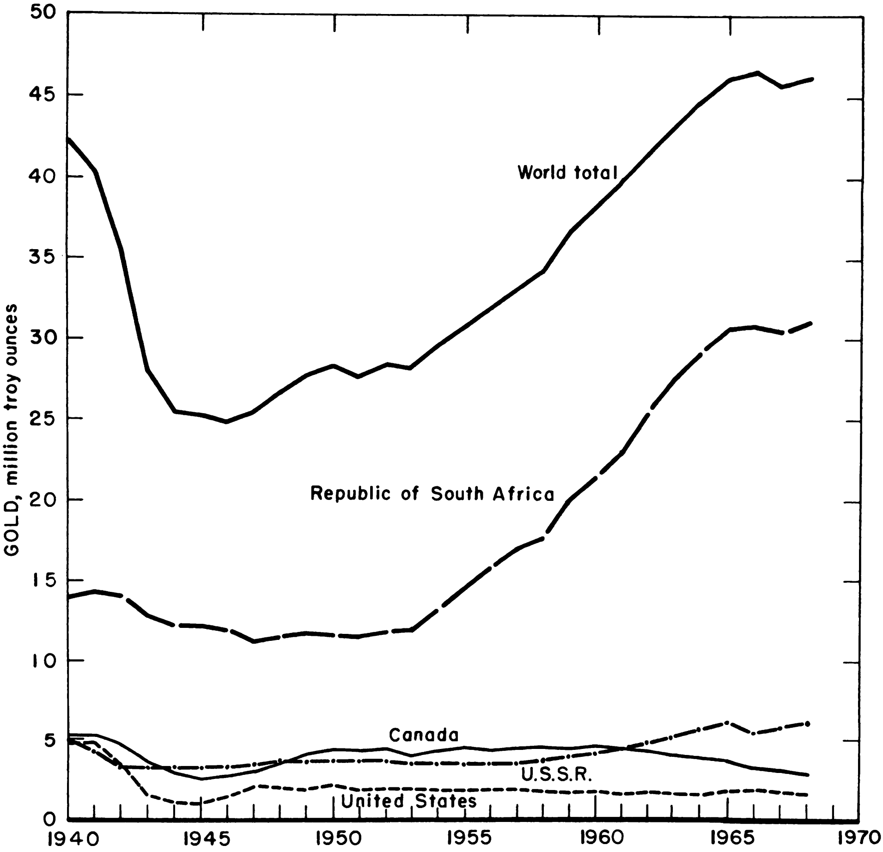

Figure 4.—World production of gold.

visions of the Emergency Gold Mining Assistance Act (EGMA).

The Hollinger mine, Canada's premier gold mine, closed in March after having produced gold valued at more than $580 million since 1912. The Preston mine, with a production record of $57 million in gold, closed in April. Tech Hughes, in the Kirkland Lake district, also closed after having produced $108 million in gold since 1917. Surluga mines in Ontario began operation at its 750-ton-per-day plant in Ontario on a developed reserve of 277,000 tons of ore averaging 0.25 per ton.

Geographic distribution of gold production in Canada follows:

Province or Territory	Troy ounces	
	1967	1968
Atlantic Provinces	26,911	10,103
Quebec	830,912	744,853
Ontario	1,500,149	1,370,366
Prairie Provinces	97,995	82,258
British Columbia	121,191	116,520
Yukon	14,216	23,240
Northwest Territories	370,625	340,678
Total	2,961,999	2,688,018

Source: Dominion Bureau of Statistics. V. 38, No. 12, March 1969.

Lode gold mines contributed about 81 percent of the total production; nearly all of the remainder was recovered as a byproduct from base metal mines. Gold recovery from placer operations was less than 1 percent. Average employment at lode gold mines was about 9,000 persons.

Giant Yellowknife Mines, Ltd., and integrated subsidiaries, the leading gold producer in 1968, reported a significant gain in tons milled and gold output. The company milled 374,717 tons of ore averaging 0.63 ounce per ton yielding 210,358 ounces of gold and 24,627 ounces of silver with a total value of $8.8 million. Metallurgical recovery dropped slightly to 88.5 percent. Operating costs increased $0.48 to $16.08 per ton milled at yearend. Reserves of developed ore at the Giant and contiguous mines totaled 1.69 million tons averaging 0.72 ounce compared with 2.04 million tons averaging 0.70 ounce per ton in 1967. A major part of the company's production from contiguous mines received cost aid under the EGMA.[7]

Dome Mines Ltd. reported small gains in gold production at its Dome and Campbell Red Lake mines. At the Dome mine the company milled 712,900 tons yielding 180,668 ounces of gold valued at $6.91 million. Operating costs increased 57 cents per ton to $10.81, this was equivalent to $42.67 per ounce of gold compared with $40.48 in 1967. Dome ore reserves were estimated at 1.93 million tons averaging 0.27 compared with 2.03 million tons of the same grade at the end of 1967. Payments received under EGMA averaged $8.88 per ounce. At the Campbell Red Lake Mine 261,768 tons averaging 0.70 ounce per ton were milled yielding 183,127 ounces of gold valued at $7.98 million. Estimated ore reserves at Campbell yearend totaled 1.29 million tons averaging 0.69 ounce per ton, an increase of 9,100 tons over last year. Operating costs were $11.36 per ton milled, 90 cents per ton more than in 1967.[8]

Kerr-Addison Mines Ltd. reported a 10-percent drop in gold output to 179,943 ounces in 1968. Average daily tonnage treated at its Kerr-Addison Mine declined from 1,417 in 1967 to 1,395 in 1968 with an average grade of 0.36 ounce per ton compared with 0.39 ounce in 1967. The company sold about 40 percent of its gold output under EGMA to the Mint at a price of $42.51 per ounce including a $4.61 assistance payment. The remainder was sold at the free market price of $43.37 per ounce. At yearend, estimated ore reserves were 3.25 million tons averaging 0.46 ounce of gold per ton compared with 3.75 million tons averaging 0.45 ounce a year earlier. About 700 persons were employed. From the commencement of milling in May 1938 to the end of 1968, 8.62 million ounces of gold valued at $309.48 million were produced from 32.47 million tons of ore with an average gold content of 0.27 ounce per ton.[9]

Colombia.—International Mining Corp. reported production from its dredging operations and its underground mine of 100,473 ounces, about 8 percent less than in 1967 and approximately 42 percent of the country's total output. A small dredge began operations in August making a total of four dredges operating in the Departments of the Choco and Narino during the year. About 15.5 million cubic yards were dredged. Proven reserves at yearend were 163.7 million cubic yards averaging 18.8 cents per yard compared with 173.2 million yards averaging 17.2 cents per yard at the end of 1967. Production and earnings declined at the Frontino mine.[10]

Pato Consolidated Gold Dredging Ltd., controlled by International Mining Corp. reported a 13-percent drop in gold output to 76,684 ounces. The company operated five dredges in the Nechi river area during the year, treating 25.6 million cubic yards of gravel averaging 11.4 cents per yard compared with 26.6 million yards averaging 12.6 cents per yard in 1967. At yearend, total workable reserves, both fully developed and partially developed, totaled 267.1 million cubic yards with an average unit value of 15.9 cents equivalent to about 10 years of operations under the present economic conditions.[11]

Philippines.—Gold production rose for the fifth consecutive year in 1968 to the highest level since 1942. Total output was 527,355 ounces, about 7 percent more than in 1967. Of the major gold producers, Benguet Consolidated produced 260,168 ounces; Lepanto Consolidated, 88,505; Itogon-Suyoc Mines, 55,838; and Philex Mining Corp. 37,518 ounces.

---

[7] Giant Yellowknife Mines Ltd. Annual Report. 1968, pp. 3–6.

[8] Dome Mines Ltd. Report to Shareholders, 1968, including copies of reports of Sigma Mines (Quebec) Ltd. and Campbell Red Lake Mines Ltd. DM. pp. 12–15; C.R.L.M. pp. 10–11.

[9] Kerr-Addison Mines Ltd. Annual Report. 1968, 15 pp.

[10] International Mining Corp. Annual Report. 1968, pp. 5–6.

[11] Pato Consolidated Gold Dredging Ltd. Thirty-fifth Annual Report. 1968, 9 pp.

Table 14.—World producers of aluminum

(Thousand short tons)

Country, company, and plant location	Annual capacity, end 1968	Participants
FREE WORLD		
NORTH AMERICA		
United States:		
Aluminum Company of America (Alcoa):		
Alcoa, Tenn	125	
Badin, N.C	100	
Evansville, Ind	175	
Massena, N.Y	125	
Point Comfort, Tex	175	
Rockdale, Tex	225	
Vancouver, Wash	100	
Wenatchee, Wash	175	
Total	1,200	
Reynolds Metals Co.		
Arkadelphia, Ark	55	
Jones Mills, Ark	109	
Listerhill, Ala	194.5	
Longview, Wash	176	
Massena, N.Y	115	
San Patricio, Tex	105.5	
Troutdale, Oreg	140	
Total	895	
Kaiser Aluminum & Chemical Corp.		
Chalmette, La	260	
Mead, Wash	206	
Ravenswood, W. Va	163	
Tacoma, Wash	61	
Total	690	
Anaconda Aluminum Co., Columbia Falls, Mont	175	The Anaconda Company
Consolidated Aluminum Corp. (Conalco), New Johnsonville, Tenn.	140	Swiss Aluminium Ltd. (Alusuisse).
Harvey Aluminum, Inc., The Dalles, Oreg	91	Harvey 49 percent, Martin Marietta Corp. 41 percent.
Intalco Aluminum Corp., Bellingham, Wash	270	American Metal Climax, Inc. 50 percent; Howmet Corp. 25 percent; Péchiney Enterprises, Inc. 25 percent.
Ormet Corp. (Ormet), Hannibal, Ohio	240	Olin Mathieson Chemical Corp., 50 percent; Revere Copper & Brass Corp., Inc. 50 percent.
Total United States	3,701	
Canada:		
Aluminum Company of Canada, Ltd.:[1]		Alcan Aluminium Ltd. (Alcan).
Arvida, Quebec	373	
Isle Maligne (Alma), Quebec	115	
Shawinigan, Quebec	70	
Beauharnois, Quebec	44	
Kitimat, British Columbia	280	
Canadian British Aluminium Co. Ltd. (CBA), Baie Comeau, Quebec.	115	Reynolds Metals 83.5 percent; Tube Investments Ltd. 16.5 percent.
Total	997	
Mexico:		
Aluminio, S.A. de C.V., Vera Cruz	33	Alcoa 49 percent, Government 51 percent.
Total North America	4,731	
SOUTH AMERICA		
Brazil:		
Aluminio Minas Gerais, S.A., Saramenha	26	Alcan.
Cia. Brasileira de Aluminio S.A. (C.B.A.), Sorocaba, Saõ Paula.	23	Government 20 percent; Votorantim Group 80 percent.
Total	49	

See footnote at end of table.

moderate increase in tons milled, yield per ton, working revenue, working costs, and working profits. Tons milled totaled 2.4 million yielding 0.46 ounce per ton at a working unit cost of $6.58. Yearend ore reserves remained unchanged at 9.5 million tons averaging 0.52 ounce per ton across a stoping width of 59 inches. Kinross Mines in the first full year of production treated 1.4 million tons of ore yielding 0.34 ounce per ton at a working cost of $7.21 and a working profit of $5.16 per ton. Development footage dropped to 54,109. Of 14,470 feet sampled 6,090 feet proved payable at an average of 364 inch-dwt. Ore reserves at yearend increased 700,000 tons to 2.3 million tons but average grade and width were down slightly to 0.36 ounce per ton across 48 inches.[13]

Consolidated Gold Fields Ltd. reported that gold production at its 10 operating mines increased to 5.4 million ounces, equivalent to 18 percent of the total South African gold output. The Group's five producing mines on the West Wits Line—West Driefontein, Doornfontein, Libanon, Venterpost and Kloof—contributed 94.5 percent of the working profit. The Kloof mine began production in January, and preparatory work was begun at the new East Driefontein Mine during the year. The company stated that gold production at West Driefontein reached a record of 2.5 million ounces notwithstanding the flooding in the No. 4 shaft area which curtailed operations after October 26. The milling rate was expected to be restored to about 85 percent of capacity by July 1969. Owing to delay in shaft sinking, the Kloof mine will achieve a milling rate of 100,000 tons per month by January 1969 some 6 months later than forecast. It is expected that the milling rate will be increased to 180,000 tons per month in the last quarter of 1969.

At East Driefontein extensive drilling has indicated an ore reserve of 85 million tons with an average grade of 0.52 ounce per ton. Three reefs will be worked and initial underground development is being carried out from the West Driefontein No. 4 Shaft. The company, which holds a 32-percent interest in East Driefontein, stated that ore milling will begin at a rate of 50,000 tons per month in 1971 and will be increased progressively thereafter to the maximum planned rate of 200,000 tons per month by 1976.[14]

TECHNOLOGY

The Bureau of Mines reported significant progress under its Heavy Metals Program the purpose of which is to stimulate gold production by improving techniques of extracting gold from ores not amenable to conventional treatment methods. A technically feasible process of recovering gold from refractory carbonaceous ore by chemical and electrolytic oxidation treatment prior to cyanidation was demonstrated. The gold occurring in ore as organic compounds was liberated by oxidation using sodium chloride which passivates the absorptive properties of the ore. Gold recovery of over 90 percent was obtained by subsequent cyanidation on ores containing 0.3 ounce per ton as compared with only 6 to 32 percent extraction obtained by direct cyanidation with oxidation pretreatment. If scaled-up pilot plant tests prove commercial feasibility, gold reserves could be substantially increased and production expanded.

Laboratory tests by the Bureau of Mines disclosed that sea water contains about 11 parts of gold per trillion parts or 0.001 cent worth per ton. Initial concentration of the gold was accomplished by solvent extraction followed by evaporation of the gold-laden organic for further concentration and atomic adsorption analysis of the gold in the concentrated organic. Radioactive gold–195 was added to the sea water to monitor the gold through the preconcentration and analytical steps. The experimental results effectively demonstrated that in any solvent extraction process the solvent losses would be many times the value of the gold recovered.

A new gold and silver detector using californium 252 as a neutron source was developed by the Atomic Energy Commission and the U.S. Geological Survey. When metals such as gold and silver are bombarded with neutrons they give off characteristic gamma rays which identify the metals present. The detector is useful in logging samples containing small amounts of gold and other metals.

---

[13] Union Corp. Ltd. Report and Accounts for the Year ended 31 December 1968.

[14] Consolidated Gold Fields Ltd. 81st Annual Report. 1968, pp. 22–26.

Westinghouse Electric Corp. developed a new process using titanium and gold films to increase substantially the reliability of integrated circuits assembled from separate components—transistors, resistors, capacitors, diodes, and their connecting wires. Essentially the new technique is a three-step process which seals the integrated circuit more effectively against its environment, against chemical instability, and against certain electrical changes. The new "Goldilox" integrated circuits are reported to be sealed so well that they have operated under water for more than an hour.

Preliminary tests by the Bureau of Mines showed that satisfactory recovery of gold can be obtained from relatively coarse sized, oxidized sedimentary ores by heap leaching with cyanide. Capital expenditures and operating costs for this method are much less than for conventional cyanide milling. The method could apply to deposits that are either too small or too low grade to warrant construction of a conventional mill and for low-grade portions of gold deposits where simultaneous operation of existing mills and heap leaching could increase treatment capacity and output at little additional expense.

A new method of detecting traces of mercury in rocks, soils, and waters that are rich in organic matter was developed at the Colorado School of Mines. This new geochemical tool utilizes an atomic absorption spectrometer after hot acid digestion of the samples for rapid measurement and analysis of many heavy metals and may prove to be a major refinement in geochemical exploration for a variety of metals including gold and silver.

IBM and Sel-Rex Corp. developed an acid-type gold plating process which provided better metallurgical characteristics than was obtained previously by a cyanide-type bath for gold plating printed circuits. The new process, a modification of the Sel-Rex Autonex process, was adopted for IBM automated gold plating operations.

The Bureau of Mines developed a process for recovering gold and refining tin-lead solders from scrap solder discarded by the electronics industry. Contaminated solder was refined by electrotransport in a molten-salt chloride electrolyte. Refined solder was recovered at the cathode and gold and other metal impurities were concentrated at the anode. Gold concentration was increased from 60 to 15,000 ounces per ton without any significant loss. The gold was then reclaimed by conventional fire-refining methods.

Table 2.—Mine production of recoverable gold in the United States, by months

(Troy ounces)

Month	1967	1968	Month	1967	1968
January	145,433	90,524	August	118,137	145,578
February	145,846	82,615	September	114,879	134,628
March	160,756	85,054	October	119,187	138,534
April	147,570	131,259	November	104,097	121,615
May	138,951	137,704	December	102,895	122,992
June	151,185	133,158			
July	135,251	154,631	Total	1,584,187	1,478,292

Table 3.—Twenty-five leading gold-producing mines in the United States in 1968, in order of output

Rank	Mine	County and State	Operator	Source of gold
1	Homestake	Lawrence, S. Dak	Homestake Mining Co	Gold ore.
2	Carlin	Eureka, Nev	Carlin Gold Mining Co	Do.
3	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold-silver ores.
4	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
5	Knob Hill	Ferry, Wash	Knob Hill Mines, Inc	Gold ore.
6	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
7	Copper Queen-Lavender Pit	Cochise, Ariz	do	Copper ore.
8	Veteran Pit	White Pine, Nev	Kennecott Copper Corp	Do.
9	Idarado	Ouray and San Miguel, Colo	Idarado Mining Co	Copper-lead-zinc ore.
10	San Manuel	Pinal, Ariz	Magma Copper Co	Copper ore.
11	Copper Canyon	Lander, Nev	Duval Corp	Do.
12	Yuba Unit	Yuba, Calif	Yuba Consolidated Gold Fields	Placer.
13	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
14	Hogatza River	Yukon River Region, Alaska	United States Smelting Refining and Mining Co	Placer.
15	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
16	Magma	Pinal, Ariz	Magma Copper Co	Do.
17	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co	Lead-zinc ore.
18	Iron King	Yavapai, Utah	McFarland & Hullinger	Lead-zinc ore.
19	Liberty Pit	White Pine, Nev	Kennecott Copper Corp	Copper ore.
20	Christmas	Gila, Ariz	Inspiration Consolidated Copper Co	Do.
21	Continental	Grant, N. Mex	United States Smelting Refining and Mining Co	Do.
22	Cornwall	Lebanon, Pa	Bethlehem Mines Corp	Magnetite-pyrite ore.
23	Chino	Grant, N. Mex	Kennecott Copper Corp	Copper ore.
24	Marvel Creek	Kuskokwim River Region, Calif	Marvel Creek Mining Co	Placer.
25	Oriental	Sierra, Calif	Dickey Exploration Co	Gold ore.

Table 4.—Mine production of recoverable gold in the United States, by States

(Troy ounces)

State	1964	1965	1966	1967	1968
Alaska	58,416	42,249	27,325	22,948	21,262
Arizona	153,676	150,566	142,528	80,844	95,999
California	71,028	62,885	64,764	40,570	15,682
Colorado	42,122	37,228	31,915	21,181	22,638
Idaho	5,677	5,078	5,056	4,838	3,227
Montana	29,115	22,772	25,009	9,786	13,385
Nevada	90,469	229,050	366,903	434,993	317,382
New Mexico	6,110	9,506	9,295	5,188	6,630
Oregon	661	499	281	186	23
Pennsylvania	[1] 94,308	[1] 90,674	[1] 85,000	[1] 73,337	[1] 54,453
South Dakota	616,913	628,259	606,467	601,785	593,052
Tennessee	133	122	141	181	140
Utah	287,674	426,299	438,736	288,350	334,419
Washington	(1)	(1)	(1)	(1)	(1)
Wyoming	6	3	-----------	-----------	-----------
Total	1,456,308	1,705,190	1,803,420	1,584,187	1,478,292

[1] Production of Pennsylvania and Washington combined to avoid disclosing individual company confidential data.

Table 5.—Production of gold in the United States, by States, by type of mine, and by class of ore yielding gold, in terms of recoverable metal, in 1968

State	Placer (troy ounces of gold)	Lode					
		Gold ore		Gold-silver ore		Silver ore	
		Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	21,124	100	138	-----	-----	-----	-----
Arizona	4	72	68	59,762	109	491	6
California	13,143	3,264	1,546	3,075	152	269	70
Colorado	1,707	351	125	2,355	381	70,292	284
Idaho	6	124	136	27	77	479,476	793
Montana	22	225	142	12,383	1,622	53,444	988
Nevada	37	777,346	280,275	-----	-----	27,014	224
New Mexico	31	-----	-----	3,086	1,047	-----	-----
Oregon	7	15	13	-----	-----	-----	-----
South Dakota	1,021	1,921,653	592,031	-----	-----	-----	-----
Tennessee	-----	-----	-----	-----	-----	-----	-----
Utah	-----	-----	-----	118,117	1,045	23,819	679
Other States [1]	-----	76,631	52,571	-----	-----	-----	-----
Total	37,102	2,779,781	927,045	198,805	4,433	654,805	3,044
Percent of total gold	3		63		(2)		(2)

State	Lode					
	Copper ore		Lead ore		Zinc ore	
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold
Alaska	-----	-----	-----	-----	-----	-----
Arizona	76,612,638	89,419	-----	-----	-----	-----
California	52	40	5,933	64	-----	-----
Colorado	1,397	6	1,217	114	257,871	495
Idaho	32,310	791	156,107	711	19,259	9
Montana	10,079,643	9,769	4,940	449	-----	-----
Nevada	10,671,047	36,004	8,769	36	1,151	4
New Mexico	6,685,066	4,931	43	1	63,728	278
Oregon	828	3	-----	-----	-----	-----
South Dakota	-----	-----	-----	-----	-----	-----
Tennessee	-----	-----	-----	-----	-----	-----
Utah	28,344,008	264,731	387	74	-----	-----
Other States [1]	24	29	-----	-----	363,078	4
Total	132,427,013	405,723	177,396	1,449	705,082	790
Percent of total gold		27		(2)		(2)

State	Lode						Refinery production [3] (troy ounces of gold
	Lead-zinc copper-zinc, and copper-lead-zinc ores		Old tailings, etc.		Total		
	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	Short tons	Troy ounces of gold	
Alaska	-----	-----	-----	-----	100	21,262	12,500
Arizona	118,152	5,278	45,995	1,115	76,837,110	95,999	99,190
California	63,297	493	285	[4] 174	76,175	15,682	15,280
Colorado	719,929	19,467	1,788	59	1,055,200	22,638	20,750
Idaho	665,371	702	45	2	1,352,719	3,227	3,200
Montana	869	68	19,944	325	10,171,448	13,385	16,450
Nevada	68,239	69	20	733	11,553,586	317,382	323,450
New Mexico	64,994	340	46	2	6,816,963	6,630	7,680
Oregon	-----	-----	-----	-----	843	23	20
South Dakota	-----	-----	-----	-----	1,921,653	593,052	621,960
Tennessee	1,624,400	140	-----	-----	1,624,400	140	130
Utah	556,288	67,193	30,741	697	29,073,360	334,419	333,740
Other States [1]	197,882	[4] 1,849	-----	-----	637,610	[5] 54,453	84,890
Total	4,079,421	95,599	98,864	3,107	141,121,167	1,478,292	1,539,250
Percent of total gold		6		(2)		100	

[1] Includes Pennsylvania and Washington.
[2] Less than ½ unit.
[3] Source: U.S. Bureau of the Mint.
[4] Includes byproduct gold recovered from tungsten ore.
[5] Includes byproduct gold recovered from magnetite-pyrite ore.

Table 6.—Gold produced in the United States from ore, old tailings, etc., in 1968 by States and methods of recovery, in terms of recoverable metal

State	Total ore, old tailings, etc., treated [1] (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters	
		Thousand short ton [2]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Alaska	(2)	-------	-------	-------	59	138	-------	--------
Arizona	96,196	95,799	-------	-------	2,507,093	90,517	397	5,478
California	76	70	862	11	15,215	1,016	7	650
Colorado	1,056	1,048	2,527	-------	141,078	18,091	8	313
Idaho	1,710	1,647	78	-------	191,534	2,908	64	235
Montana	10,215	10,099	2	-------	248,056	9,953	116	3,408
Nevada	11,650	11,555	302	279,989	280,281	35,603	95	1,451
New Mexico	7,001	6,958	-------	-------	302,198	5,549	44	1,050
Oregon	1	1	10	-------	69	3	(2)	3
South Dakota	1,922	1,922	390,270	201,761	---------	-------	-------	--------
Tennessee	5,969	5,969	-------	-------	299,307	140	-------	--------
Utah	29,079	28,878	-------	-------	810,882	331,855	201	2,564
Other States	639	639	-------	855	47,952	53,568	(2)	30
Total	165,514	164,585	394,051	482,616	4,843,724	549,341	932	15,182

[1] Includes some nongold-bearing ores not separable; excludes tonnages of magnetite-pyrite, tungsten, and uranium ores from which gold was recovered as a byproduct.

[2] Less than ½ unit.

Table 7.—Gold produced at amalgamation and cyanidation mills in the United States and percentage of gold recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Gold recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1964	453,736	254,771	31.2	17.5	42.7	8.6
1965	460,271	392,171	27.0	23.0	44.2	5.8
1966	[r] 432,130	[r] 519,631	[r] 24.0	[r] 28.8	42.1	5.1
1967	400,836	609,714	25.3	38.5	32.1	4.1
1968	394,051	482,616	26.7	32.6	38.2	2.5

[r] Revised.

[1] Crude ores and concentrates.

Table 8.—Gold production at placer mines in the United States, by methods of recovery

Method and year	Mines producing	Washing plants	Material treated (thousand cubic yards)	Gold recoverable		
				Thousand troy ounces	Value (thousands)	Average value per cubic yard
Bucketline dredging:						
1964	13	13	14,382	103	$3,604	$0.251
1965	9	11	13,685	83	2,889	.211
1966	9	11	13,384	75	2,631	.197
1967	10	10	5,448	48	1,690	.310
1968	4	4	3,770	20	778	.206
Dragline dredging:						
1964	19	13	195	2	68	.350
1965	10	11	[1] 632	[2] 2	57	.090
1966	9	9	[1] 227	[2] 2	70	.308
1967	4	4	[1] 55	[2] 1	21	[3] .981
1968	3	3	[1] 81	[2] 1	54	[3] .499
Hydraulicking:						
1964	11	11	30	(4)	10	.323
1965	6	6	4	(4)	3	.750
1966	4	4	41	(4)	9	.211
1967	4	5	7	1	27	[3] .478
1968	---	---	---	---	---	---
Nonfloating washing plants:						
1964	55	49	[1] 585	[2] 14	489	.836
1965	48	64	[1] 501	[2] 11	391	.779
1966	41	59	[1] 548	[2] 13	456	.834
1967	41	57	[1] 797	[2] 13	472	[3] .449
1968	26	37	[1] 384	[2] 8	325	[3] .498
Underground placer, small-scale mechanical and hand methods, and suction dredge:						
1964	87	56	49	6	212	4.292
1965	70	48	68	4	140	2.059
1966	57	23	26	2	56	2.159
1967	53	19	63	2	59	.925
1968	50	22	[1] 241	[2] 8	296	[3] 1.277
Total placers:						
1964	185	142	[1] 15,241	[2] 125	4,383	.287
1965	143	140	[1] 14,890	[2] 100	3,480	.234
1966	120	106	[1] 14,226	[2] 92	3,222	.227
1967	112	95	[1] 6,370	[2] 65	2,269	[3] .332
1968	83	66	[1] 4,476	[2] 37	1,457	[3] .292

---

[1] Excludes tonnage of material treated at commercial sand and gravel operations recovering byproduct gold.
[2] Includes gold recovered at commercial sand and gravel operations recovering byproduct gold.
[3] Gold recovered as a byproduct at sand and gravel operations not used in calculating average value per cubic yard.
[4] Less than ½ unit.

Table 9.—U.S. Gold consumption in industry and the arts [e]

(Thousand troy ounces)

Industry group	1964	1965	1966	1967	1968
Jewelry and arts	2,743	3,317	3,700	3,755	3,908
Dental	446	538	540	772	771
Industrial, including space and defense	1,014	1,421	1,822	1,767	1,925
Total	[r] 4,203	5,276	6,062	6,294	6,604

---

[e] Estimated by Office of Domestic Gold and Silver Operations.
[r] Revised.

Table 10.—U.S. exports of gold in 1968, by countries

Destination	Ore and base bullion		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Belgium-Luxembourg	103,940	$3,907		
Canada			547	$20
Colombia			821	32
Germany, West	14,379	504	30	1
Singapore			643,015	22,506
Syrian Arab Republic			250,000	8,750
United Kingdom	63,066	2,354	22,886,593	801,085
Total	181,385	6,765	23,781,006	832,394

Table 11.—U.S. imports of gold in 1968, by countries

Country	Ore and base bullion		Refined bullion	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
Argentina	3	(1)		
Australia	17,104	$564	250	$10
Austria			90	3
Belgium-Luxembourg	14	(1)	124,878	4,471
Canada	31,809	1,209	3,471,339	131,830
Chile	10,436	365		
Colombia	784	27		
Ecuador	15	(1)		
El Salvador			123	4
France			66,428	2,655
Germany, West	1,886	47	67,358	2,590
Honduras	5,196	162	1,230	46
Hong Kong	266	9		
Jamaica	16	1		
Japan	1,767	71	67,946	2,378
Mexico	5,824	216	689	27
Netherlands			177,995	6,943
Netherlands Antilles	22	1		
Nicaragua	50,990	1,924	5,727	220
Norway	230	9		
Panama	24	1		
Peru	11,526	403		
Philippines	61,597	2,330	426,376	14,931
South Africa, Republic of	12,666	444		
Switzerland			442,201	17,682
Taiwan	27	1		
U.S.S.R.			9,147	360
United Kingdom	2,010	71	868,363	34,228
Venezuela			713	30
Total	213,662	7,855	5,730,853	218,408

---

[1] Less than ½ unit.

Table 12.—Value of gold imported into and exported from the United States

(Thousand dollars)

Year	Imports	Exports
1966	$42,004	$457,333
1967	32,547	1,005,199
1968	226,263	839,159

Table 13.—World production of gold by countries

(Troy ounces)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada	3,835,454	3,606,031	[r] 3,319,474	2,961,999	2,668,018
Costa Rica [e]	3,000	570	570	500	500
Haiti	8,090	6,719	5,071	[e] 6,000	3,100
Honduras	3,401	4,090	4,274	5,924	6,150
Mexico	209,976	215,795	213,609	165,287	176,952
Nicaragua	225,581	198,152	199,108	177,702	193,008
United States [2]	1,456,308	1,705,190	1,803,420	1,584,187	1,478,292
South America:					
Argentina	303	84	[r] 160	35	NA
Bolivia	128,576	94,314	86,982	55,069	68,266
Brazil	142,524	155,031	167,955	171,700	170,070
Chile	64,992	58,897	[r] 69,626	58,135	53,145
Colombia	364,991	319,362	280,823	257,668	237,480
Ecuador	17,681	11,512	10,901	6,738	8,659
French Guiana	4,823	----------	632	7,584	5,099
Guyana	2,111	2,077	3,045	2,379	4,088
Peru	92,503	105,183	94,978	95,559	82,502
Surinam	8,258	6,269	5,159	[e] 4,500	[e] 5,100
Venezuela	33,536	23,660	[r] 16,900	20,000	20,600
Europe:					
Finland	[r] 22,049	[r] 18,027	[r] 15,471	20,281	21,380
France	54,303	57,389	[r] 60,154	62,703	[e] 52,000
Germany, West	2,402	1,865	1,071	916	[e] 1,000
Portugal	21,316	21,541	18,776	27,103	18,679
Spain	23,534	8,295	450	NA	NA
Sweden	117,672	[r] 118,090	[r] 79,573	60,668	49,737
U.S.S.R. [e] [3]	4,650,000	5,030,000	5,370,000	5,700,000	6,040,000
Yugoslavia	106,773	103,911	84,942	68,064	[e] 70,000
Africa:					
Cameroon	739	1,286	900	990	466
Central African Republic	75	23	48	----------	----------
Congo (Brazzaville)	3,567	3,697	4,080	[e] 4,000	[e] 4,000
Congo (Kinshasa)	188,693	90,408	[r] 159,821	153,520	169,975
Ethiopia	[e] 27,300	24,236	21,256	[e] 21,000	35,973
Gabon, Republic of	42,760	37,134	34,433	29,250	16,724
Ghana	864,917	755,191	684,395	762,609	727,122
Kenya	12,480	11,420	11,988	33,366	31,974
Liberia [4]	1,824	1,701	4,351	5,111	3,216
Malagasy Republic	440	598	852	752	543
Mozambique	40	32	22	22	6
Nigeria	244	80	61	39	215
Rhodesia, Southern	575,386	544,100	[e] 550,000	500,000	500,000
South Africa, Republic of	29,111,524	30,553,874	30,879,700	30,532,880	31,094,466
Sudan	877	300	[e] 200	[e] 200	[e] 200
Swaziland	2,078	1,619	308	----------	----------
Tanzania	93,040	90,819	55,473	18,486	17,473
Uganda	24	36	3	14	----------
Upper Volta	32,665	32,504	16,075	----------	----------
Zambia	5,033	5,196	[e] 5,000	[e] 5,000	[e] 5,000
Asia:					
Burma [e]	200	200	200	200	200
Cambodia [e]	6,000	4,500	4,000	4,000	4,000
China, mainland [e]	60,000	60,000	60,000	50,000	50,000
India	148,504	130,628	120,244	101,628	115,357
Indonesia	5,813	6,752	4,122	7,752	5,968
Japan [5]	253,300	264,842	[r] 256,394	252,993	238,301
Korea:					
North [e]	160,000	160,000	160,000	160,000	160,000
South [2]	75,791	62,836	60,765	63,337	62,405
Malaysia:					
Malaya	7,296	[r] 4,051	2,959	1,290	1,454
Sarawak	3,115	2,602	2,611	2,521	2,718
Philippines	425,770	[r] 435,545	453,546	490,557	527,355
Taiwan	[r] 19,376	[r] 35,270	[r] 45,867	35,563	20,994
Oceania:					
Australia	963,834	877,643	[r] 916,985	801,009	796,635
British Solomon Islands	101	310	[e] 200	[e] 200	[e] 200
Fiji	100,493	109,095	112,567	111,028	106,784
New Zealand	8,948	12,136	8,965	10,703	8,626
Papua and New Guinea	38,977	32,494	28,106	27,671	26,144
Total [6]	[r] 44,841,381	[r] 46,225,212	[r] 46,579,621	[r] 45,708,392	46,168,319

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Gold is also produced in Bulgaria, Czechoslovakia, Rumania, and small quantities probably in East Germany, Hungary, and Thailand. Data for these countries are not available. Data are also lacking on clandestine activities.

[2] Mine production.

[3] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[4] Year ending August 31 of year stated.

[5] Refinery production for Japan was as follows: 1964, 460,171 ounces; 1965, 519,163 ounces; 1966, 555,476 ounces; 1967, 678,133 ounces; and 1968, 614,336 ounces.

[6] Total is of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/61

Graphite

By Lewis K. Weaver[1]

Domestic production of manufactured graphite increased to 213,300 short tons in 1968 from 208,100 tons in 1967. Domestic output of natural graphite was slightly less than in 1967, while imports of natural graphite increased from 56,400 tons to 67,800 tons. Manufactured graphite and natural graphite are not interchangeable for some end uses, and manufactured graphite commands a higher price.

Legislation and Government Programs.—Government stocks of various natural graphites totaled 43,653 tons at yearend 1968 compared with the revised figure of 44,073 tons at yearend 1967. This reduction resulted from the sale of 302 tons of Malagasy crystalline flake and 118 tons of other crystalline graphite. Quantities of graphite authorized for commercial disposal by negotiated offers over a period of years[2] include 14,813 tons of natural Malagasy crystalline flake and 1,410 tons of natural other than Ceylon and Malagasy, crystalline.

Table 1.—Salient natural graphite statistics

	1964	1965	1966	1967	1968
United States:					
Consumption [1] ... short tons	[2] 54,000	[2] 47,100	[2] 48,400	38,300	38,500
Value [1] ... thousands	[2] $7,026	[2] $6,390	[2] $6,629	$5,700	$5,904
Exports ... short tons	2,000	3,200	3,200	3,600	4,200
Value ... thousands	$333	$419	$428	$460	$509
Imports for consumption [1] ... short tons	47,200	58,100	56,700	56,700	67,900
Value ... thousands	$1,943	$2,387	$2,545	$2,348	$2,495
World: Production ... short tons	683,039	669,400	538,816	396,106	392,359

[1] Includes some artificial graphite.
[2] Includes some estimates.

DOMESTIC PRODUCTION

The only domestic producer of natural graphite for the seventh consecutive year was the Southwestern Graphite Co., Burnet, Tex. The output in 1968 was less than in 1967.

---

[1] Petroleum engineer, Bureau of Mines, Dallas, Tex.

[2] Disposal plans approved by the affected Federal agencies and Government-industry consultation limit the quantities to be sold in a given period. GSA solicitations and invitations-for-bid should be consulted for actual quantities being offered for sale.

Table 2.—Government yearend stocks of natural graphite

(Short tons)

Type of graphite	National stockpile	Supplemental stockpile	Total all stockpiles
Malagasy crystalline flake:			
Objective	10,800	------	10,800
Excess:			
Stockpile grade	15,029	------	15,029
Total	25,829	------	25,829
Malagasy crystalline fines:			
Objective	5,296	1,904	7,200
Excess:			
Stockpile grade	------	[r]5	[r]5
Nonstockpile grade	------	[r]1	[r]1
Total	5,296	[r]1,910	[r]7,206
Ceylon amorphous lump:			
Objective	4,296	1,204	5,500
Excess:			
Stockpile grade	106	224	330
Nonstockpile grade	56	------	56
Total	4,458	1,428	5,886
Other than Ceylon and Malagasy, crystalline:			
Objective	2,800	------	2,800
Excess:			
Stockpile grade	1,024	------	1,024
Nonstockpile grade	908	------	908
Total	4,732	------	4,732

[r] Revised.

Source: Office of Emergency Planning. Statistical Supplement Stockpile Report to The Congress. OEP-4, July–December 1968.

Synthetic graphite production (principally from petroleum coke) increased about 5,200 tons over 1967 production. Total 1968 production was 213,292 tons, valued at $117.7 million. The eight companies producing synthetic graphite and their plant locations are as follows:

Company	Location
Airco Speer	Niagara Falls, N.Y.
Becker Brothers Carbon Co	Cicero, Ill.
The Carborundum Co	Hickman, Ky.
Do	Sanborn, N.Y.
The Dow Chemical Co	Midland, Mich.
Great Lakes Carbon Corp	Rosamond, Calif.
Do	Morganton, N.C.
Do	Niagara Falls, N.Y.
The Ohio Carbon Co	Cleveland, Ohio
Stackpole Carbon Co	St. Marys, Pa.
Union Carbide Corp	Columbia, Tenn.
Do	Niagara, Falls, N.Y.

Two firms, Becker Brothers Carbon Co. and The Ohio Carbon Co., were new producers in 1968.

CONSUMPTION AND USES

The continued increase in the amount of amorphous graphite used for refractories and foundry facings was chiefly responsible for the increase in consumption of natural graphite. The need for coarse flake graphite is decreasing because silicon carbide-graphite crucibles are replacing clay-graphite crucibles which require about twice as much graphite. The demand for manufactured graphite continues to increase for use in nuclear reactors. (Natural graphite cannot be used.) Other uses of manufactured graphite include electrodes for electrosmelting, anodes for the electrochemical industries, crucibles and vessels, refractories, cloth and fibers, electric motor brushes, and parts for jet engines and missiles.

Table 3.—Consumption[1] of natural graphite in the United States in 1968, by uses

Use	Crystalline		Amorphous[2]		Total[3]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Batteries	W	W	W	W	W	W
Bearings	90	$45	(4)	(4)	90	$45
Brake linings	452	143	493	$174	945	317
Carbon brushes	75	39	494	239	569	278
Crucibles, retorts, stoppers, sleeves, and nozzles	3,879	616	(4)	(4)	3,879	616
Foundry facings	1,862	328	7,370	796	9,232	1,124
Lubricants	342	118	2,587	357	2,929	475
Packings	195	98	181	55	376	153
Paints and polishes	15	4	146	19	161	23
Pencils	1,351	480	536	105	1,887	585
Refractories	(5)	(5)	7,004	690	7,004	690
Rubber	64	30	196	48	260	78
Steelmaking	770	129	5,216	402	5,986	531
Other[6]	1,547	420	3,642	569	5,189	989
Total	10,642	2,451	27,865	3,453	38,507	5,904

W Withheld to avoid disclosing individual company confidential data; included in "Other".

[1] Consumption data incomplete. Excludes numerous small consuming firms.

[2] Includes mixtures of natural and manufactured graphite.

[3] Data may not add to totals shown because of independent rounding.

[4] Included with crystalline to avoid disclosing individual company confidential data.

[5] Included with amorphous to avoid disclosing individual company confidential data.

[6] Includes adhesives, chemical equipment and processes, electronic products, gray iron castings, powdered-metal parts, small packages, specialties and items indicated by symbol W.

PRICES

Actual prices for natural graphite are negotiated between buyer and seller and cover a wide range of specifications.

	Per pound
Nos. 1 and 2 flake graphite, 90 to 95 percent carbon	$0.29 to $0.32
Powdered crystalline graphite:	
88 to 90 percent carbon	.20 to .245
90 to 92 percent carbon	.225 to .255
95 to 96 percent carbon	.29 to .32
Powdered amorphous graphite	.065 to .12
Powdered amorphous graphite, minimum of 97 percent carbon	.305 to .33

Source: Oil Paint and Drug Reporter.

Yearend prices quoted for flake and crystalline graphite in the Engineering and Mining Journal, f.o.b. source, were as follows:

	Per short ton	
	1967	1968
Flake and crystalline graphite, bags:		
Ceylon	$76 to $228	$74 to $214
Germany, West	112 to 610	112 to 610
Malagasy Republic	86 to 204	86 to 204
Norway	85 to 145	90 to 155
Amorphous, nonflake, cryptocrystalline graphite (80 to 85 percent carbon):		
Mexico (bulk)	$19 to $22	$19 to $22
South Korea (bulk)	15	18
Hong Kong (bags)	21	23

FOREIGN TRADE

Exports of natural graphite, 4,169 tons, were the largest on record, and represented an increase of approximately 17 percent over those of 1967. About half the exports went to Canada.

An alltime record of 67,817 tons of natural graphite was imported during 1968, an approximate 20-percent increase over that of 1967. Most came from Mexico, which has a multimillion-ton reserve of natural graphite.

Table 4.—U.S. exports of natural graphite, by countries

Destination	Amorphous, crystalline flake, lump, or chip, and natural n.e.c.[1]			
	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	19	$2	3	$1
Australia	97	10	69	8
Brazil	65	10	19	2
Canada	1,490	171	1,959	228
Chile	60	8	44	6
Colombia	16	3	45	7
Denmark	4	(2)	6	1
Dominican Republic	2	(2)	21	3
Finland	-----	-----	22	2
France	186	22	185	28
Germany, West	82	8	137	14
India	11	1	3	(2)
Ireland	-----	-----	30	3
Israel	11	2	-----	-----
Italy	67	13	111	12
Japan	128	20	246	30
Leeward and Windward Islands	64	8	-----	-----
Libya	64	7	-----	-----
Mexico	403	50	450	51
Netherlands	205	25	90	12
Peru	-----	-----	22	3
Philippines	79	11	74	10
Spain	7	1	-----	-----
Sweden	15	2	-----	-----
Switzerland	28	4	9	1
Taiwan	25	3	-----	-----
United Kingdom	300	45	409	60
Venezuela	173	30	170	32
Other countries	23	4	45	5
Total	3,569	460	4,169	509

[1] Not elsewhere classified.
[2] Less than ½ unit.

Table 5.—U.S. imports for consumption of natural and artificial graphite, by countries

Year and country	Natural						Artificial		Total	
	Crystalline flake		Crystalline lump, chip, or dust		Other natural, crude and refined		Short tons	Value (thousands)	Short tons	Value (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)				
1966	6,483	$712	------	------	50,154	$1,821	111	$12	56,748	$2,545
1967:										
Austria	40	4	------	------	28	3	------	------	68	7
Canada	-----	------	------	------	1	1	250	9	251	10
Ceylon	-----	------	------	------	3,842	441	------	------	3,842	441
France	2	1	------	------	------	------	------	------	2	1
Germany, West	215	43	14	4	1,504	190	27	19	1,760	256
Korea, South	-----	------	------	------	995	26	------	------	995	26
Malagasy Republic	4,451	457	------	------	28	3	------	------	4,479	460
Mexico	-----	------	------	------	42,632	893	------	------	42,632	893
Norway	-----	------	------	------	2,389	222	------	------	2,389	222
Sweden	-----	------	------	------	110	9	------	------	110	9
Switzerland	-----	------	------	------	------	------	10	5	10	5
Thailand	-----	------	------	------	56	8	------	------	56	8
Turkey	55	6	------	------	------	------	------	------	55	6
United Kingdom	-----	------	------	------	------	------	26	4	26	4
Total	4,763	511	14	4	51,585	1,796	313	37	56,675	2,348
1968:										
Austria	-----	------	------	------	28	2	------	------	28	2
Canada	-----	------	------	------	57	4	------	------	57	4
Ceylon	-----	------	------	------	2,222	261	------	------	2,222	261
Germany, West	829	170	161	50	1,516	194	------	------	2,506	414
Hong Kong	-----	------	------	------	225	5	------	------	225	5
Italy	-----	------	30	10	33	4	7	2	70	16
Korea, South	-----	------	------	------	460	12	------	------	460	12
Malagasy Republic	3,896	411	25	2	104	16	------	------	4,025	429
Mexico	-----	------	------	------	55,160	1,035	------	------	55,160	1,035
Mozambique	5	4	------	------	------	------	------	------	5	4
Netherlands	2	4	------	------	------	------	------	------	2	4
Norway	-----	------	------	------	2,999	269	------	------	2,999	269
South Africa, Republic of	-----	------	30	2	------	------	------	------	30	2
Switzerland	-----	------	------	------	------	------	10	4	10	4
Turkey	28	2	------	------	------	------	------	------	28	2
United Kingdom	-----	------	------	------	------	------	95	31	95	31
Total	4,760	591	246	64	62,804	1,802	112	37	67,922	2,495

WORLD REVIEW

West Germany.—Fried. Krupp reportedly sold its 30-percent interest in Graphitwerk Kropfmuhl AG., one of the world's largest producers and processors of crystalline natural graphite, to Ludolph Struwe & Co., of Hamburg. The other shareholders, Bayerische Hypotheken & Wechsel Bank and H. Aufhauser of Munich, each hold about one-third of the share capital.

Table 6.—World production of natural graphite by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Mexico	33,441	44,548	42,717	44,853	NA
United States	W	W	W	W	W
South America:					
Argentina	245	202	[r] 173	236	NA
Brazil	[e] 1,270	1,292	1,408	3,192	NA
Europe:					
Austria	112,697	94,529	87,677	34,768	[e] 33,070
Germany, West	14,796	15,005	14,488	13,066	NA
Italy	[r] 1,798	[r] 1,290	1,179	2,069	[e] 1,433
Norway	7,983	9,348	[r] 8,756	8,411	[e] 8,267
U.S.S.R. [e]	66,000	66,000	72,000	72,000	77,000
Africa:					
Malagasy Republic	14,521	18,756	18,040	16,414	NA
South Africa, Republic of	1,042	447	1,161	740	NA
South-West Africa	276	396	400	NA	NA
Asia:					
Ceylon (exports)	11,957	9,789	11,051	11,428	[2] 11,963
China (mainland) [e]	45,000	45,000	45,000	33,000	34,000
Hong Kong	795	---------	---------	21	558
Japan	2,701	2,482	2,428	1,890	NA
Korea:					
North [e]	77,000	77,000	83,000	83,000	83,000
South	291,517	283,316	144,338	71,018	143,068
Total [3]	[r] 683,039	[r] 669,400	[r] 533,816	[r] 396,106	392,359

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Graphite is known to be produced in Czechoslovakia, India, and Southern Rhodesia, but production data are not available.

[2] January through November 1968.

[3] Total is of listed figures only.

Table 7.—Ceylon: Exports of graphite, by countries

(Short tons)

Destination	1967	1968 [1]
Australia	440	527
France	384	310
Germany, West	67	212
India	991	660
Japan	2,754	4,840
Pakistan	81	60
Poland	83	86
United Kingdom	2,512	2,346
United States	3,836	2,743
Other countries	280	179
Total	11,428	11,963

[1] January through November 1968.

Table 8.—Malagasy Republic: Exports of graphite, by countries

(Short tons)

Destination	1966	1967
Australia	113	55
Canada	55	56
France	2,808	4,321
Germany, West	1,609	1,784
India	96	207
Italy	1,003	944
Japan	1,127	2,230
Netherlands	242	104
Poland	99	243
Spain	229	255
Turkey	------	3
United Kingdom	5,505	2,818
United States	5,550	4,817
Other countries	97	19
Total	18,533	17,856

Graphitwerk Kropfmuhl AG's mine in Bavaria, near the Austrian border, produces several grades of graphite including crucible flake (92 to 95 percent carbon). The Rhodesian company, Rho-German Graphite (Pvt) Ltd., 50 percent owned by Graphitwerk Kropfmuhl AG, has been mining crystalline graphite from an open pit mine in the Karoi district, Southern Rhodesia, since mid-1966.

Another subsidiary of Graphitwerk Kropfmuhl AG is the Kyrstagon-Graphit-Kompagnie (GmbH).[3]

---

[3] Bureau of Mines. Mineral Trade Notes. V. 65, No. 2, February 1968, p. 12.

TECHNOLOGY

Graphite may be a component in future airframes if composite structures of high-temperature, organic resins are perfected. Materials engineers are researching composites in an effort to reduce airframe weight as much as 25 percent.[4]

A process using a pure graphite mold has been used successfully for increasing accuracy of titanium castings.[5] The mold is produced by applying pressure to fibrous carbon or graphite obtained from burned newspapers.

Various trade journals and patents indicate a continuing interest in new and expanded uses of graphite for lubricants including one designed for use in space; for use in atomic reactors; for use in various graphite structures; and many other uses.

---

[4] Steinburg, Morris. Composites Are Keys to Better Airframes. Steel, v. 163, No. 22, Nov. 25, 1968, pp. 64a–64d.

[5] Metals Week. Graphite Adds Accuracy to Titanium Casting. V. 39, No. 17, Apr. 22, 1968, p. 11.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/175

Gypsum

By Paul L. Allsman [1]

Gypsum production rose in 1968, reversing the trend of the previous 3 years. Consumption of gypsum products rose markedly for home construction, cement and chemical manufacture, pottery art, agriculture, and industrial fillers. Mexico announced plans for its first two gypsum wallboard plants near Mexico City. Several elemental sulfur and sulfate fertilizer plants using gypsum as a raw material were put onstream. Research on a number of processes for producing byproduct cement, sulfuric acid, lime, fertilizers, sulfur, and soda ash from raw gypsum, anhydrite, or waste gypsum ponds promised important future industrial uses for gypsum.

Domestic production of crude gypsum rose 9 percent, while imports rose 15 percent. Production of wall board products increased 15 percent, and total value of board products increased 13 percent.

Table 1.—Salient gypsum statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Active mines and plants [1]	106	113	121	113	112
Crude:[2]					
Mined	10,684	10,033	9,647	9,393	10,018
Value	$38,874	$37,375	$35,681	$34,383	$36,775
Imports for consumption	6,258	5,911	5,479	4,722	5,454
Calcined:					
Produced	9,440	9,320	8,434	7,879	8,844
Value	$135,877	$133,028	$119,747	$115,467	$133,239
Products sold (value)	$431,717	$419,620	$376,871	$362,268	$404,739
Exports (value)	$1,808	$2,032	$2,674	$2,918	$3,556
Imports for consumption (value)	$14,687	$13,328	$17,281	$11,353	$13,058
World: Production	51,575	52,894	53,676	52,145	NA

NA Not available.
[1] Each mine, calcining plant, or combination mine and plant is counted as 1 establishment.
[2] Excludes byproduct gypsum.

DOMESTIC PRODUCTION

Of the 76 mines operated 59 were open pit, 16 were underground; and one was both. Eighty-seven percent of the total output came from 41 mines operated by companies having calcining equipment. By State, the leading crude gypsum producers were Michigan, 15 percent; California and Iowa, 14 percent each; and Texas, 11 percent.

Domestic or imported gypsum was calcined at 76 plants that had 231 kettles and 72 other pieces of calcining equipment. A total of 9.6 billion square feet of board products was reported in 1968 with a value of $342.7 million, compared with 8.3 billion square feet of board products valued at $302.6 million in 1967. Natural gas, oil, and coal were used as fuel at various plants.

The new elemental sulfur plant of Elcor Chemical Corp. in Culberson County, Tex., was readied for production at yearend. Full-scale operation was planned following trial runs. The plant will produce 1,000 long tons per day of sulfur from gypsum quarried locally at the Rock House facility. One ton of sulfur will require 6 tons of crude gypsum. Power Gas Corp. of America completed a new plant at Hanford, Calif., to produce 200 tons per day of ammonium sulfate fertilizers from gypsum. The process will also produce byproduct chalk.

---

[1] Mineral specialist, Division of Mineral Studies.

Several gypsum board plants were expanded in 1968. American Gypsum Division of Susquehanna Corporation expanded the boardline at its Albuquerque, N. Mex., wallboard plant from 65 to 110 feet per minute. Installation of a new forming line, new handling equipment, and a new type of gypsum board kiln enabled a 40-percent reduction in the length of the building. The Celotex Corp. announced expansion of the boardline at its Port Clinton, Ohio, wallboard plant.

The trend toward merging with closely allied industries continued, as the gypsum industry attempted to further diversify and expand its product lines. National Gypsum Co. announced agreement to acquire Binswanger Glass Co. of Richmond, Va. American Gypsum Corp. announced a merger with Atlantic Research Corp.; new headquarters will be in Alexandria, Va. Johns-Manville Corp. announced the $16.5 million purchase of six properties from the Gypsum Division of The Fibreboard Corp. Included are gypsum-calcining plants at South Gate, Calif., Florence, Colo., and Apex, Nev.; and crude gypsum quarries at Apex and Lovelock, Nev., and Coaldale, Colo.

Table 2.—Crude gypsum mined in the United States, by States

(Thousand short tons and thousand dollars)

State	1967			1968		
	Active mines	Quantity	Value	Active mines	Quantity	Value
California	9	1,241	$3,150	9	1,360	$3,603
Colorado	4	77	265	6	98	354
Idaho	--------	--------	--------	1	8	18
Iowa	5	1,219	5,186	5	1,351	5,838
Michigan	5	1,422	5,085	5	1,405	5,196
Nevada	3	409	1,412	3	552	1,534
New Mexico	5	155	588	5	146	549
New York	5	570	3,118	5	570	2,925
Oklahoma	8	804	2,266	8	931	2,565
South Dakota	1	12	49	1	16	65
Texas	7	984	3,419	7	1,039	3,616
Other States [1]	23	2,500	9,845	21	2,547	10,517
Total	75	9,393	34,388	76	10,018	36,775

[1] Includes the following States to avoid disclosing invididual company confidential data; Louisiana, Montana (1968), Virginia (1968), and Washington, 1 mine each; Arkansas, Indiana, Kansas, Montana (1967), Ohio, Utah, and Virginia (1967), 2 mines each; Wyoming, 3 mines; and Arizona, 4 mines.

Table 3.—Calcined gypsum produced in the United States, by States

(Thousand short tons and thousand dollars)

State	1967					1968				
	Active plants	Quantity	Value	Calcining equipment		Active plants	Quantity	Value	Calcining equipment	
				Kettles	Other [1]				Kettles	Other [1]
California	7	584	$7,641	16	9	7	742	$10,675	17	9
Florida	W	W	W	W	W	3	433	W	9	2
Georgia	3	464	8,832	15	------	3	519	9,910	15	------
Iowa	5	768	11,477	22	4	5	848	13,100	22	4
Michigan	4	362	5,929	10	1	4	369	6,396	10	1
Nevada	W	W	W	W	W	3	303	3,251	11	7
New Jersey	4	347	4,056	9	4	4	356	4,308	9	3
New York	7	836	12,265	22	5	7	907	13,803	26	3
Ohio	3	334	4,960	9	1	3	359	5,158	9	1
Texas	7	723	10,519	27	3	7	826	12,081	28	3
Other States [2]	36	3,461	49,788	94	50	30	3,182	54,557	75	39
Total	76	7,879	115,467	224	77	76	8,844	133,239	231	72

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes rotary and beehive kilns, grinding-calcining units, Holo-Flites, and Hydrocal cylinders.

[2] Comprises States and number of plants as follows: Arizona, Arkansas, Colorado, Connecticut, Delaware, Illinois, Massachusetts, Montana, New Hampshire, Pennsylvania, Washington, 1 mine each; Kansas, Louisiana, Maryland, New Mexico, Oklahoma, Utah, Virginia, and Wyoming, 2 mines each; and Florida (1967), Indiana, and Nevada (1967), 3 mines each.

CONSUMPTION AND USES

Thirty-two percent of the 1968 total domestic crude gypsum production was utilized uncalcined for cement, chemical, or as gypsum manufacture. In California, 52 percent of the output of crude gypsum was sold uncalcined for agricultural purposes.

In 1968, 1.53 million private, nonfarm housing starts were begun, 12 percent more than in 1967. This resulted in a 17 percent increase in wallboard consumption over that of 1967.

Forecasts indicated that 1969 industrial construction would be 6 percent higher, and the rate of new commercial housing about 5 percent higher, than in 1968. The Gypsum Association predicted the upward trend in housing would continue. Fifty percent of the new housing was anticipated to be apartment construction.

United States Gypsum Company, in conjunction with John Hancock Mutual Life Insurance Co. and Allied Mortgage and Development Co., undertook a program of large-volume, low-cost, computerized house building for low and moderate income families. Emphasis was placed on renovation of slums and tenement areas by trained dry-wall contracting crews; on the use of colored, decorated, or pictured wallboard systems; on the development of new molding, taping, or studding types of construction systems for use in office buildings, hospitals, and schools; and on more research on fireproof and soundproof paneling and wallboard systems.

Interest began to develop in cheap sources of gypsum for use in making

Table 4.—Gypsum products (made from domestic, imported, and byproduct gypsum) sold or used in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1967 Quantity	1967 Value	1968 Quantity	1968 Value
Uncalcined:				
Portland-cement retarder	3,154	$14,704	3,439	$16,037
Agricultural gypsum	1,280	5,466	1,388	6,222
Other uses [1]	77	712	108	886
Total	4,511	20,882	4,935	23,145
Calcined (industrial):				
Plate-glass and terra-cotta plasters	33	498	30	464
Pottery plasters	50	1,246	54	1,400
Dental and orthopedic plasters	15	614	15	624
Industrial molding, art, and casting plasters	108	2,408	119	3,078
Other industrial uses [2]	87	3,522	83	3,348
Total	293	8,288	301	8,914
Building:				
Plasters:				
Basecoat	561	10,928	536	10,522
Veneer plaster (basecoat and finishes)	34	1,664	46	2,315
Mill-mixed basecoats (sanded and perlited)	328	8,485	301	7,977
To mixing plants	W	W	W	W
Gaging and molding	80	2,006	76	1,974
Prepared finishes	8	758	8	694
Roof deck	334	5,582	319	5,432
Keene's cement	16	462	17	517
Other [3]	12	583	11	576
Total	1,373	30,468	1,314	30,007
Prefabricated products [4]	[5] 7,647	302,630	[5] 8,776	342,673
Total	---------	333,098	---------	372,680
Grand total, value	---------	362,268	---------	404,739

W Withheld to avoid disclosing individual company confidential data; included with "Other."

[1] Includes uncalcined gypsum for use in filler and rock dust, in brewer's fixe, in color manufacture, and for unspecified uses.

[2] Includes dead-burned filler, granite polishing, and miscellaneous uses.

[3] Includes joint filler; patching, painter's, insulating, and unclassified building plasters; and quantity and value indicated by symbol W.

[4] Excludes tile.

[5] Includes weight of paper, metal, or other materials.

cement, sulfuric acid, or other products.

Cost of byproduct gypsum from ponds, an unwanted byproduct of wet-process phosphoric acid manufacture, is quoted as low as 50 cents per ton. Cement made from this byproduct gypsum, using a variety of new processes, can be sold for about $2 per barrel. Twenty million tons of waste gypsum are produced each year by U.S. phosphoric plants.[2]

Basic development of new gypsum products continued, as the Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia published results of fire-resistance tests of cast plasters.[3]

Table 5.—Prefabricated products sold or used in the United States, by products

Product	1967			1968		
	Thousand square feet	Thousand short tons [1]	Value (thousands)	Thousand square feet	Thousand short tons [1]	Value (thousands)
Lath:						
⅜ inch	809,407	596	$21,330	827,223	607	$21,698
½ inch	131,325	126	4,884	162,399	158	6,010
Other [2]	7,828	10	403	9,283	11	433
Total	948,560	732	26,617	998,905	776	28,141
Wallboard:						
¼ inch	104,023	59	2,473	108,605	62	2,574
⅜ inch	1,354,634	1,012	45,035	1,430,485	1,056	47,351
½ inch	4,966,794	4,789	184,877	5,880,978	5,588	212,995
⅝ inch	654,821	793	34,771	854,679	1,005	41,997
1 inch [3]	8,648	17	763	7,759	16	688
Total	7,088,920	6,670	267,919	8,282,506	7,727	305,605
Sheathing	192,838	192	5,835	221,569	222	6,754
Laminated board	[4] 5,694	6	352	[4] 6,608	8	402
Formboard	44,645	47	1,907	41,131	48	1,771
Grand total [5]	8,280,657	7,647	302,630	9,550,719	8,776	342,673

[1] Includes weight of paper, metal, or other materials.
[2] Includes a small amount of ¼-inch, ⅝-inch, and 1-inch lath.
[3] Includes a small amount of 5⁄16-inch, ¾-inch, 1⅝-inch, and 3¾-inch wallboard.
[4] Area of component board and not of finished products.
[5] Excludes tile, for which figures are withheld to avoid disclosing individual company confidential data.

PRICES

Prices (base rates) for truckload lots of gypsum products in 20 U.S. cities were published monthly in Engineering News-Record. Neat plaster averaged $35.51 per ton and ranged from $26 in Boston to $52.50 in Seattle. Gaging plaster sold for an average of $41.74 per ton and ranged from $31 at Pittsburgh to $56.60 at Minneapolis. One-half-inch gypsum board averaged $62.04 per thousand square feet and ranged from $44 at Detroit to $74 at Seattle. Quotations for ¾-inch board averaged $54.40 and ranged from $38 at Detroit to $67 at Seattle. Three-eighths-inch gypsum lath averaged $44.79 and ranged from $29 at Detroit to $61 at Seattle. Tongue and groove sheathing averaged $60.01 and ranged from $40 at Detroit to $100 at Los Angeles.

FOREIGN TRADE

Imports of crude gypsum increased 15 percent over those of 1967, paralleling increased domestic consumption of gypsum during the year. Imported gypsum was 35 percent of the total crude gypsum supply. Canada provided 77 percent of the total crude imports; Mexico, 17 percent; Jamaica, 4 percent; and the Dominican Republic, 2 percent.

---

[2] Chemical Week. They're Moving Gypsum Mountains. V. 103, No. 5, Aug. 3, 1968, pp. 37, 38.

[3] Ridge, M. J., and A. Adami. Factors Determining the Fire Resistance of Building Elements of Cast Gypsum. Division of Building Research, CSIRO, Report Fl. 13, 1968, 13 pp.

Table 6.—U.S. exports of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude, crushed or calcined		Other manufactures, n.e.c., value	Total value
	Quantity	Value		
1966	38	$1,458	$1,216	$2,674
1967	39	1,707	1,211	2,918
1968	39	1,688	1,868	3,556

Table 7.—U.S. imports for consumption of gypsum and gypsum products

(Thousand short tons and thousand dollars)

Year	Crude (including anhydrite)		Ground or calcined		Alabaster manufactures,[1] value	Other manufactures, n.e.c., value	Total value
	Quantity	Value	Quantity	Value			
1966	5,479	$15,761	2	$91	$985	$444	$17,281
1967	r 4,563	9,723	r 2	86	855	689	11,353
1968	5,474	11,384	2	89	932	653	13,058

r Revised.
[1] Includes imports of jet manufactures, which are believed to be negligible.

Table 8.—U.S. imports for consumption of crude gypsum (including anhydrite), by countries[1]

(Thousand short tons and thousand dollars)

Country	1967		1968	
	Quantity	Value	Quantity	Value
Canada	r 3,674	r $7,857	4,254	$8,976
Brazil	(2)	9	---------	---------
Dominican Republic	87	282	90	290
France	1	3	---------	---------
Italy	(2)	2	(2)	4
Jamaica	145	505	226	734
Mexico	656	1,065	904	1,380
Total	r 4,563	9,723	5,474	11,384

r Revised.
[1] New Zealand revised to none.
[2] Less than ½ unit.

WORLD REVIEW

Angola.—Tenneco-Angola, Inc., was granted exclusive rights to prospect and exploit sulfur, gypsum, and anhydrite in specified areas of Angola for 3 years.

Brazil.—Power Gas Corp. of America announced its intent to construct a new sulfuric acid and cement plant at São Paulo for Chemoleum Corp. of New York. The plant will use the Marchon process and will utilize byproduct gypsum from acid manufacture as the raw material.

Canada.—United Gypsum Corp. Ltd., a subsidiary of Alscope Consolidated Ltd., awarded a contract for a new sulfuric acid and cement plant to Power Gas Corp. of America. The proposed plant will be at Skookumchuck, British Columbia, and will utilize local deposits of gypsum and anhydrite. The new gypsum wallboard plant of B.A.C.M. Ind., Ltd., at Saskatoon, Saskatchewan, was described. The ultramodern, automated plant obtains gypsum from Amaranth, Manitoba Plant capacity is in excess of 200,000 square feet per 24-hour day.[4]

Chile.—M. W. Kellogg Co. began feasi-

---

[4] Toles, George E. New Canadian Gypsum Plant Is First in Saskatchewan. Rock Prod., v. 71, No. 8, August 1968, pp. 54–56.

Table 9.—World production of gypsum, by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada [2]	6,360,644	6,305,589	5,976,125	5,175,380	6,145,188
United States	10,684,049	10,033,226	9,646,368	9,392,784	10,018,000
Middle America:					
Cuba [e]	27,859	27,558	27,558	NA	NA
Dominican Republic	120,917	98,656	100,181	130,855	[e] 110,281
Guatemala	7,828	10,354	13,228	12,566	8,620
Honduras	5,203	6,657	12,985	15,347	NA
Jamaica	215,184	233,520	[r] 212,746	184,086	230,000
Mexico	1,284,251	1,192,418	1,268,837	1,076,297	1,384,000
Nicaragua	6,063	5,512	9,921	11,023	15,700
Trinidad and Tobago	2,531	2,056	2,219	4,020	4,840
South America:					
Argentina	170,353	271,512	317,688	[p] 295,419	NA
Brazil	93,040	79,959	88,431	NA	NA
Chile	131,351	111,451	131,858	[r] 146,107	133,400
Colombia	118,498	123,459	126,766	[e] [r] 85,980	NA
Paraguay	860	2,425	2,756	1,984	2,580
Peru	55,155	84,139	70,371	[p] 71,650	NA
Venezuela [e]	82,453	94,688	94,799	93,696	112,000
Europe:					
Austria [2]	626,189	681,139	856,482	[r] 813,555	[e] 815,709
Bulgaria	142,198	191,802	[r] 179,677	[r] 187,393	[e] 187,393
Czechoslovakia	386,911	364,865	392,422	[e] [r] 408,957	NA
France [2]	5,414,608	5,525,564	5,811,635	[e] [r] 5,621,781	[e] 5,511,550
Germany:					
East [3]	295,199	286,601	288,805	[e] [r] 308,647	NA
West (marketable)	1,409,163	1,432,767	1,450,973	[r] 1,368,362	[e] 1,410,957
Greece	[r] 155,001	[r] 198,416	[r] 227,076	231,485	[e] 286,997
Ireland	255,401	240,304	[e] 240,304	[e] 240,304	NA
Italy	[r] 2,690,739	[r] 3,395,115	3,604,554	[e] 3,637,623	[e] 3,637,628
Luxembourg	7,890	6,034	[e] 6,614	12,125	[e] 11,023
Poland	837,756	837,756	837,756	859,802	859,802
Portugal	71,627	89,208	124,451	114,896	NA
Spain [e]	3,097,491	3,355,432	3,575,689	3,637,623	3,692,788
U.S.S.R	4,633,009	4,788,435	[e] 4,954,883	5,170,936	5,346,203
United Kingdom [2]	5,056,296	4,910,791	4,803,867	5,062,910	[e] 5,125,741
Yugoslavia	170,570	184,311	185,953	188,412	[e] 187,398
Africa:					
Algeria [e]	192,904	192,904	192,904	192,904	NA
Angola	11,077	11,261	4,680	NA	NA
Ethiopia	[e] 4,409	[e] 2,756	5,512	6,727	NA
Kenya	30,858	38,001	37,195	44,584	NA
Libya	440	2,056	2,756	[e] 2,756	[e] 2,756
Morocco [e]	55,115	77,162	88,185	99,208	NA
Niger	----------	1,653	[e] 1,653	1,906	NA
South Africa, Republic of	264,645	335,036	326,878	339,062	348,385
Sudan	4,982	4,729	2,118	1,984	NA
Tanzania	3,260	5,027	5,320	17,062	4,917
Tunisia	[e] 19,842	[e] 19,842	[e] 19,842	[e] 11,023	NA
United Arab Republic	371,975	504,708	505,524	[e] 275,577	NA
Asia:					
Burma	10,086	496	[e] 2,205	[e] 2,205	3,968
China (mainland) [e]	661,386	661,386	661,386	551,155	551,155
Cyprus	49,604	67,213	49,671	50,376	[e] 50,706
India	972,783	1,278,680	1,425,287	1,265,452	NA
Iran [e] [4]	1,322,772	1,653,465	1,984,158	1,995,181	2,094,389
Iraq [e]	551,155	551,155	551,155	551,155	NA
Israel [e] [5]	121,254	121,254	93,696	93,696	NA
Japan	827,582	716,354	658,797	644,004	[e] 661,386
Lebanon	----------	----------	29,762	33,069	NA
Mongolia [e]	22,046	22,046	22,046	27,558	27,558
Pakistan	215,357	164,716	[r] 110,612	112,832	[e] 121,254
Philippines	45,148	30,300	16,897	16,737	[e] 16,535
Saudi Arabia	11,640	24,911	26,109	30,591	[e] 33,069
Syrian Arab Republic	22,046	[e] 16,535	[e] 16,535	[e] 16,535	[e] 16,535
Taiwan	18,843	30,598	9,274	[r] 18,141	6,213
Thailand	46,187	12,390	43,683	68,008	NA
Turkey [e]	220,462	242,508	242,508	242,508	264,554
Oceania: Australia	880,885	933,545	[r] 897,740	870,671	NA
Total [6]	[r] 51,575,030	[r] 52,894,406	[r] 53,676,066	[r] 52,144,672	NA

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Gypsum is also produced in Rumania and Switzerland, but production data are not available. Production in Bolivia and Ecuador is negligible.

[2] Includes anhydrite.

[3] Crude production estimates based on calcined figures.

[4] Year ended March 20 of year following that stated.

[5] Year ended March 31 of year following that stated.

[6] Total is of listed figures only.

bility studies for a new sulfuric acid and cement plant at Patillos, for Marcona Corp. The plant will use the Oesterreichische Stickstoffwerke AG. (OSW) process from Linz, Austria, and will utilize natural anhydrite as a raw material.

Greece.—Litton Industries, Inc., planned to increase production to 50,000 tons per year from gypsum deposits on Crete.

Mexico.—Kaiser Gypsum Co. was completing plans for a moderate-sized gypsum wallboard plant at Puebla, 86 miles southwest of Mexico City. This will be the first wallboard plant in Mexico. Kaiser Gypsum Co. also exports crude gypsum from San Marcos Island in the Gulf of California. United States Gypsum Company also announced plans for a new multimillion-dollar gypsum products plant near Puebla. The company's subsidiary, Yeso Mexicana S.A., will quarry the gypsum for the new plant.

Switzerland.—Gypsum is the only important industrial mineral mined. Manufacturing is performed at nine modern plants; Felsenau, Leissingen, Ennetmoos, Laufelfingen, Bex, Heimberg, Kienberg, Ruthi, and Granges.

United Kingdom.—Marchon Products Ltd. doubled production of its underground anhydrite mine to 13,500 tons per week. Underground crushing and diesel "scooptrams," which carry 10-ton loads, comprise the new mining system. Within 5 years the workings will extend under the sea, at a depth of 900 feet.

TECHNOLOGY

The gypsum industry took a giant step forward in 1968, as research and development on a number of processes for manufacturing cement, sulfuric acid, and other products were announced. The Bureau of Mines led in this research, analyzing the important basic processes for making sulfur from gypsum materials at its Salt Lake City Metallurgy Research Center. Reduction roasting of 1 ton of gypsum plus sodium chloride with coal produced 372 pounds of elemental sulfur, 1,230 pounds of sodium carbonate, and 1,290 pounds of calcium chloride. Cost of the sulfur was estimated as low as $27 per ton in a 1,000-ton-per-day plant. Continuing research by the Bureau to investigate recovery of sulfur from gypsum ores and residues, and from gaseous products of metallurgical reactions, further advanced the technology of the industry. Kinetic studies were made on production of calcium, magnesium, and potassium compounds from byproduct gypsum from phosphoric acid manufacture. In another Bureau investigation, recovery of sulfur from gypsum residues by bacterial action was studied.

Economics of gypsum processes for producing sulfur, sulfuric acid, and other products were analyzed during the year, as follow:[5]

1. Elcor, Texas: Gypsum (6 tons) yields elemental sulfur (1 ton). Cost with gypsum at 50 cents per ton is $27 to $40 per long ton of sulfur.
2. Bureau of Mines: Gypsum (6 tons) yields sulfur (1 ton) plus soda ash (3 tons). Cost of sulfur is $20 per long ton; of soda ash, $30.
3. Laseter, Texas: Gypsum microbially yields sulfur plus vitamins. Cost is $35 to $45 per long ton of sulfur.
4. Marchon, England: Gypsum 1.7 tons) yields cement plus sulfuric acid (1 ton). Cost of cement is $8 per long ton; of acid, $12.
5. Kent Feeds, Iowa: Gypsum yields lime plus sulfuric acid. Pilot plant only.
6. Power Gas, California: Gypsum yields ammonium sulfate plus chalk. Cost with ammonia at $30 per ton is $16 per ton of fertilizer.

Other signicant developments in the gypsum industry during the year included basic research on the mechanism of hydration of plaster particles. Sedimentation tests and photomicrographs were made of various plasters and mortar mixes, determining a variety of characteristics of plaster mixing. The method of disintegration of the plaster particles was proved to uniquely influence the properties of the gypsum plaster. United States Gypsum Company planned further work on this important phase of technology.[6]

---

[5] Chemical Engineering. Gypsum: Ready To Fill the Sulfur Gap? V. 75, No. 10, May 6, 1968, pp. 94–96.

[6] Lane, Marvin K. Disintegration of Plaster Particles in Water. Rock Prod., v. 71, No. 2, March 1968, pp. 60–63, 108.

Electronic color sorting was applied to gypsum beneficiation during the year. This technique makes possible the utilization of a much poorer quality of ore than is now possible. Many good grade gypsum deposits contain strata or nodules of dolomite, limestone, or shale which can be satisfactorily removed by selective screening and color sorting. The Sortex model 621M electronic color sorter detects differences in the light-reflecting properties of ore and gangue.[7]

A new source of byproduct gypsum was reported by the steel industry in 1968. In the neutralization of acid-liquor wastes by lime, calcium chloride and ferrous hydroxide precipitate (magnetite) are produced. Further reaction with sulfuric acid precipitates gypsum and forms hydrochloric acid. This neutralization process is considered the only economic solution to pickle liquor disposal.[8]

---

[7] French, Robert R. Beneficiation of Low-Grade Gypsum by Electronic Color Sorting. Trans. AIME, v. 241, 1968, pp. 331–334.

[8] Krikau, F. G. Neutralization Is Key to Acid-Liquor Waste Disposal. Chem. Eng., v. 75, No. 25, Nov. 18, 1968, pp. 124–126.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/30

Helium

By Billy J. Moore[1]

Sales of grade A helium in the United States in 1968 were 867.1 million cubic feet (MMcf), a decline of about 40 MMcf from 1967 sales. Of the total, 478.4 MMcf was sold by the Bureau of Mines, compared with 607.0 MMcf in 1967. The decline in Bureau sales was principally attributed to a greater share of the helium demand being supplied by private industry. These private plants had a total sales volume of 388.7 MMcf compared with 300.2 MMcf in 1967. Helium purchases by the Bureau of Mines under the conservation program were 3,639.8 MMcf in 1968, 21 MMcf more than in 1967.

The price of helium, f.o.b. Bureau of Mines' plants, remained at $35 per thousand cubic feet. This price was established in 1961. Helium was sold by private producers at various rates somewhat lower than the Bureau of Mines' price.

PRODUCTION

At yearend, there were 16 helium extraction plants operating in the United States. These plants may be classified in three categories: (1) Plants owned by the Federal Government and operated by the Bureau of Mines; (2) "conservation" plants, privately owned and operated, producing only crude helium (50 to 85 percent purity), almost all of which is purchased by the Bureau of Mines under the national helium conservation program; and (3) privately owned and operated plants producing helium for independent sale to commercial (non-Federal) customers.

Total production of helium from all plants during 1968 was 4,854.8 million cubic feet. This is an increase of about 3 percent over the 1967 production of 4,712.3 million cubic feet.

---

[1] Supervisory petroleum engineer, Helium Activity, Bureau of Mines, Amarillo, Tex.

Table 1.—Ownership and location of helium extraction plants in the United States

Owner or operator	Location	Type of production
Bureau of Mines	Amarillo, Tex	Grade A helium.
Do	Exell, Tex	Do.
Do	Keyes, Okla	Do.
Do [1]	Shiprock, N. Mex	Do.
Do [2]	Otis, Kans	Crude helium only.
Cities Service Helex, Inc	Ulysses, Kans	Do.
National Helium Corp	Liberal, Kans	Do.
Northern Helex Co	Bushton, Kans	Do.
Phillips Petroleum Co	Dumas, Tex	Do.
Do	Hansford Co., Tex	Do.
Kerr-McGee Corp	Navajo, Ariz	Grade A helium.[3]
Arizona Helium Corp	do	Do.
Air Reduction Co	Teec Nos Pos, Ariz	Crude helium.[4]
Alamo Chemical Co	Elkhart, Kans	Grade A helium.[3]
Kansas Refined Helium Co	Otis, Kans	Do.[3]
Cities Service Cryogenics, Inc	Scott City, Kans	Crude helium.[3] [5]
Linde Co	Amarillo, Tex	Grade A helium.[3]

[1] Plant owned and operated by Bureau of Mines through July 1968. Ownership transferred to the Navajo Tribe of Indians and operated by Air Reduction Co. under lease.
[2] Plant ceased operation April 30, 1968.
[3] Plant equipped to produce liquid helium.
[4] Crude helium is purified at Shiprock plant.
[5] Crude helium is shipped by pipeline to the Cities Service Helex plant for purification.

Table 2.—Helium production in the United States

(Million cubic feet)

Year	Production
1966	4,606.1
1967	4,712.3
1968	4,854.8

Bureau of Mines Plants.—At the beginning of 1968, the Bureau of Mines operated five Government-owned helium extraction plants. However, operations at the Otis, Kans. plant ceased at the end of April 1968, and the plant at Shiprock, N. Mex., was transferred to the Navajo Indian Tribe in July. The plant at Otis, operated as part of the conservation program, produced 15.5 million cubic feet of crude helium.

Production from the other three Bureau plants, and the Shiprock plant while under Bureau ownership, was 677.7 million cubic feet, or about 5.2 percent less than the 714.8 million cubic feet produced in 1967. Helium produced by the Bureau of Mines and not sold was stored at Cliffside Field, Tex.

Conservation Plants.—Five privately owned and operated helium extraction plants produced helium for sale to the Bureau of Mines under long-term contracts for the Government's helium conservation program. These plants produced only crude helium, principally for storage at Cliffside Field, but two of the plants sold 133.1 million cubic feet in excess of conservation contract requirements to private helium plants for purification. Some of this excess helium was stored at Cliffside Field under contract with the private producers. During 1968, the five conservation plants produced a total of 3,772.9 million cubic feet of helium. The Bureau of Mines purchased 3,639.8 million cubic feet of this total, compared with 3,618.7 million cubic feet purchased in 1967.

Table 3.—Production of grade A helium by Bureau of Mines plants

(Million cubic feet)

Plant location	Production 1967	Production 1968
Amarillo, Tex	60.8	62.0
Exell, Tex	273.8	270.2
Keyes, Okla	309.0	308.6
Shiprock, N. Mex	71.2	[1]36.9
Total	714.8	677.7

[1] Production for period Jan-July, 1968, while plant was operated by Bureau of Mines.

Table 4.—Helium purchased by the Bureau of Mines for conservation

(Million cubic feet)

Company and location of plant	1964	1965	1966	1967	1968
Northern Helex Co., Bushton, Kans	493.9	585.1	565.5	654.9	618.1
Cities Service Helex Inc., Ulysses, Kans	492.2	638.6	717.4	740.6	771.4
National Helium Corp., Liberal, Kan	1,184.4	1,310.2	1,303.7	1,245.6	1,211.6
Phillips Petroleum Co., Dumas, Tex	458.7	513.6	539.8	551.2	569.9
Phillips Petroleum Co., Hansford Co., Tex	563.9	502.1	490.7	426.4	468.8
Total	3,193.1	3,549.6	3,617.1	3,618.7	3,639.8

The helium purchased by the Bureau of Mines was transported to the Government-owned Cliffside gasfield by pipeline and was stored underground for future use. The storage operation was begun in 1962 and, at yearend, 20,329 million cubic feet of helium was in storage.

Private Plants.—The number of privately owned helium plants producing helium for sale to the non-Federal market increased from four to eight during 1968. One of

Table 5.—Helium in conservation storage

(Million cubic feet)

Year	Amount in storage on Dec. 31
1964	5,433.8
1965	9,072.8
1966	[1]12,720.2
1967	[1]16,527.0
1968	[1]20,328.5

[1] Includes helium stored for private companies under storage contracts and not owned by Bureau of Mines: 1966, 50.2 million cubic feet (MMcf); 1967, 57.4 MMcf; 1968, 69.8 MMcf.

this number is the former Bureau of Mines' plant at Shiprock, N. Mex., now operated by Air Reduction Co. for the Navajo Indian Tribe. The other three are new plants, two in Arizona and one in Kansas. This brings to three the number of private plants in both Arizona and Kansas. New Mexico and Texas have one each.

One of the new plants, Cities Service Cryogenics at Scott City, Kans., produced only crude helium, but this crude was transported by pipeline to the firm's conservation plant at Ulysses, Kans., where a purification and liquefaction plant was constructed. Another of the new plants, that of Arizona Helium Corp. at Navajo, Ariz., began operations shortly before the year ended and produced only a small amount of crude helium in December. No grade A helium was produced. The Linde Co. plant in Amarillo, Tex., purchased only crude or pure helium from other plants for purification or liquefaction. Five of these private plants have facilities for liquefaction of helium.

Production of grade A helium by privately owned extraction plants in 1968 totaled 388.7 million cubic feet. This is an increase of almost 30 percent over the 300.2 million cubic feet produced in 1967.

CONSUMPTION

Bureau of Mines sales of grade A helium dropped from 607.0 million cubic feet (MMcf) in 1967 to 478.4 MMcf in 1968. Total sales of grade A helium from both Bureau and private sources decreased from 907.2 MMcf in 1967 to 867.1 MMcf in 1968. This was a decrease of about 21 percent in Bureau sales but only about 4.4 percent in total sales. Private industry sales increased by almost 30 percent from 300.2 MMcf in 1967 to 388.7 MMcf in 1968.

All Bureau of Mines' shipments of helium were made in gaseous form in cylinders, railway tank cars, or highway semitrailers. The Bureau plant at Amarillo, Tex., is specially equipped to fill, process, load, and ship helium in standard gas cylinders (Interstate Commerce Commission 3A and 3AA cylinders), and all cylinder shipments

Table 6.—Shipments of grade A helium from Bureau of Mines plants, in 1968

(Million cubic feet)

Plant	Shipments: Federal agencies	Shipments: Non-Federal customers [1]	Shipments: Total
Amarillo, Tex	71.1	34.2	[2] 105.3
Exell, Tex	103.9	3.6	107.5
Keyes, Okla	189.8	38.9	228.7
Shiprock, N. Mex	35.6	1.3	36.9
Total	400.4	78.0	478.4

[1] A large part of this helium is redistributed by the non-Federal customers to Federal agencies and their contractors; hence, these data are not indicative of actual helium use by the Bureau's customers.

[2] The Amarillo and Exell plants are connected by pipeline primarily serving the cylinder loading facility at the Amarillo plant. Thus, shipments from the Amarillo plant exceed plant production.

Table 7.—Shipments of grade A helium from Bureau of Mines plants to various customers

(Million cubic feet)

Recipient	1967 Quantity	1967 Percent [1]	1968 Quantity	1968 Percent [1]
Federal agencies:				
Department of Defense	226.1	37.3	279.9	58.5
Atomic Energy Commission	39.3	6.5	28.5	6.0
National Aeronautics and Space Administration	147.0	24.2	86.6	18.1
Weather Bureau	5.5	.9	4.5	.9
Other	.7	.1	.9	.2
Total	418.6	69.0	400.4	83.7
Non-Federal customers [2]	188.4	31.0	78.0	16.3
Grand total	607.0	100.0	478.4	100.0

[1] Percentage of all shipments.

[2] A large part of this helium is redistributed by the Bureau's non-Federal customers to Federal agencies and their contractors; hence, the data herein are not indicative of actual helium use by non-Federal customers.

originate there. All Bureau plants have facilities to load and ship both railway tank cars and semitrailers. Containers are rated to 4,000 pounds per square inch at 70° F. The Bureau does not produce liquid helium.

Helium redistribution continued satisfactorily under contracts with the General Services Administration. The private companies purchase helium from the Bureau of Mines in bulk, repackage it in smaller containers, and distribute it to the helium-using Federal agencies. These contracts make relatively small quantities of helium readily available to the agencies and reduce freight charges for small purchases.

The largest user of helium in 1968 was again the Nation's space and missile program. Private industry and research organizations continue to use large quantities of helium each year.

Table 8.—Grade A helium used in the United States

(Million cubic feet)

Year	Quantity[1]
1964	718
1965	757
1966	948
1967	907
1968	867

[1] Includes helium produced and sold by privately owned helium extraction plants.

RESOURCES

In 1968, the survey to locate the helium resources of the United States was continued. A total of 472 natural gas samples from fields and wells in 20 States and six foreign countries were collected and analyzed for helium.

Judging from the information now available, no significant discoveries of helium were made in 1968; however, the future development of some new fields could increase estimates of reserves.

As of December 31, 1968, helium reserves of the United States were estimated to be 165 billion cubic feet. This estimate does not include the 20 billion cubic feet of helium in storage at Cliffside Field, Potter County, Tex., near Amarillo. Five major helium-bearing gasfields located in the Texas Panhandle, Oklahoma Panhandle, and southwestern Kansas contain over 80 percent of the helium reserves of the United States. These fields are (1) the Hugoton field in Kansas, Oklahoma, and Texas; (2) the Panhandle field of Texas; (3) the Keyes field in Oklahoma; (4) the Greenwood field in Kansas and Colorado; and (5) the Cliffside field in Texas. All of these fields are within 200 miles of Amarillo, Tex. The remaining helium reserves are contained in 85 gasfields located in Arizona, Colorado, Kansas, Montana, New Mexico, Oklahoma, Texas, Utah, West Virginia, and Wyoming.

FOREIGN TRADE

Export licenses for helium are issued by the Office of Munitions Control, U.S. Department of State. Exports amounted to about 2 percent of the annual consumption. Most exported helium was used in fundamental and applied research, in chromatography, and in various atomic energy applications.

WORLD REVIEW

The only helium extraction plant in operation in the free world besides those in the United States is located near Swift Current in Saskatchewan Province, Canada. The plant began production in December 1963. It processes nonflammable helium-bearing gas from a small reserve. In 1967, the plant capacity was increased from 12 million cubic feet of helium annually to 36 million cubic feet. Most of the helium produced is said to be exported to Japan and other Asian countries, although some is used domestically.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/193

Iron Ore

By John L. Morning [1]

The year 1968 was marked by a plentiful supply of iron ore, despite an unprecedented worldwide demand, as new mines, new iron ore pellet plants, and expansion of existing facilities came into production. World demand continued to grow as total world steel production rose 33 million tons over that of 1967. The domestic demand for iron ore also was strong with the steel industry producing at a high level despite a high rate of steel imports.

Reported world resources of iron ore were expected to skyrocket when the results of a worldwide United Nations study of resources is published. For North America, iron ore reserves totaled over 40 billion tons and total resources, about 225 billion tons. Exploration for new iron ore deposits continued throughout the world and several large discoveries were announced.

A high degree of interest was shown in prereduced (metalized) pellets as new plants having a total annual capacity of 3.5 million tons were under construction. No particular process predominated, with most of the plants designed to process an unusual type ore or to serve a particular marketing area.

Japan's quest for iron ore for its expanding steel industry made worldwide news with long-term contracts negotiated in numerous countries. An insight into transportation costs was obtained when a Japanese steel mill renegotiated a long-term iron ore contract with Brazil, and secured shipping costs of less than $0.50 per ton per thousand miles for delivery to Japan in carriers of 90,000 and 105,000 tons.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Salient iron ore statistics

(Thousand long tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Iron ore (usable; [1] less than 5 percent Mn):					
Production [2]	84,836	87,439	90,147	84,179	85,865
Shipments [3]	84,300	84,073	90,041	82,415	81,934
Value [3]	$802,331	$801,350	$854,134	$817,511	$836,433
Average value at mines per ton	$9.52	$9.53	$9.49	$9.92	$10.21
Exports	6,963	7,085	7,779	5,906	5,884
Value	$79,670	$80,418	$92,157	$71,585	$70,835
Imports for consumption	42,408	45,103	46,259	44,611	43,941
Value	$421,288	$443,788	$462,354	$443,918	$453,753
Consumption	132,328	131,888	134,047	127,424	131,753
Stocks Dec. 31:					
At mines [3]	10,241	12,667	12,160	12,959	15,990
At consuming plants	54,189	53,799	54,658	55,121	53,232
At U.S. docks	3,741	2,494	2,707	2,987	2,797
Manganiferous iron ore (5 to 35 percent Mn): Shipments	213	333	246	289	245
World: Production	[2] 573,449	611,187	625,799	615,538	670,943

[r] Revised.

[1] Direct shipping ore, washed ore, concentrates, agglomerates, and byproduct pyrites cinder and agglomerates.

[2] Includes byproduct ore.

[3] Excludes byproduct ore.

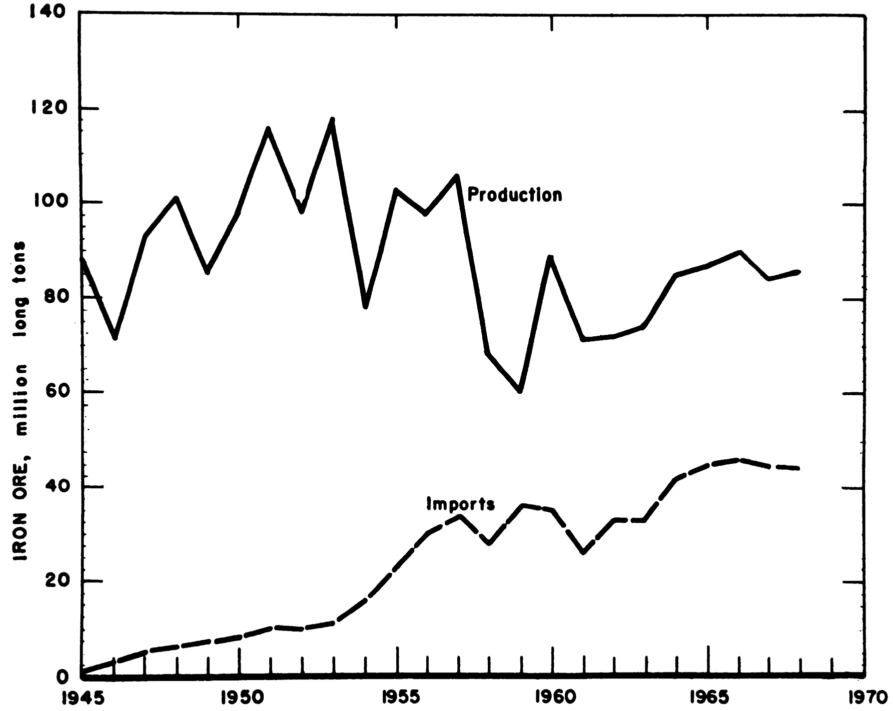

Figure 1.—United States iron ore production and imports for consumption.

DOMESTIC PRODUCTION

Domestic usable iron ore production was 2 percent above the 1967 level and increased in iron content to 59 percent from 58 percent in the prior year. The Lake Superior district recorded a 2-million-ton production increase as output in the southeastern district continued to decline. Magnetite was the preferred ore, gaining nearly 9 million tons, while hematite production dropped 6 million tons, and brown ore output dropped about 600,000 tons.

Crude ore production increased 12 million tons and in general followed the pattern of usable iron ore in that magnetite ore indicated a large increase in output, while a decline was noted for hematite and brown iron ores. Although production increased, the number of mines operating during the year dropped to 109 from 131 in 1967. The Lake Superior district recorded nearly 80 percent of the total output. Iron ore produced, by ranges, indicated that for the first time in recent history, no production was recorded in the Gogebic and Vermillion Ranges. Production in the Spring Valley Range remained at a low level. Underground mining continued to decline providing only 5 percent of domestic production.

As part of the world survey of iron ore resources conducted by the United Nations, the United States ore reserve was reported at 7.5 billion tons and potential ore at 96 billion tons for a total resource of 104 billion tons of iron ore. This estimate excluded large reserves of economically treatable taconite ores which could add a possible 3 billion tons to the total.

At midyear, the first unit trainload of iron ore pellets was shipped from the Pilot Knob Pellet Co., in southeastern Missouri, to the Granite City Steel Co. in Illinois. The new facilities at Pilot Knob, operated by the Hanna Mining Co., has an annual capacity of 1 million tons of pellets, which will be consumed by Granite City's expanded steel plant.

Early in 1969 Pickands Mather & Co. (PMC) became a wholly owned subsidiary of the Diamond Shamrock Corp. PMC acts as the manager for seven operating iron ore properties owned by major steel companies in the United States, Canada, Italy, and Japan. PMC has ownership in three of the properties. Three of the properties are in Minnesota, three in Canada, and one in Australia. Five of the properties produce iron ore pellets.

United States Steel Corp.'s (USS) domestic operations produced 18.2 million tons of iron ore, including 4.6 million tons of iron ore pellets from its taconite plant in Minnesota, according to its annual report. Shipments by wholly owned subsidiaries in Venezuela and Canada totaled 21.1 million tons.

Reportedly, USS would exploit its iron ore deposits at Klukwan, Alaska, under a joint venture with Japanese concerns, if Japanese steel companies would guarantee to purchase all of the output. The Japanese were studying the feasibility of the project including grinding and pelletizing the ore onsite or in Japan. A deterrent to the project is the titanium content of 2 to 3 percent in the ore.

Sovereign Industries Inc. (Arizona) continued discussions throughout the year with Japanese interests on a proposal to supply 5 million tons annually of iron ore pellets for 10 years. According to Sovereign and its consultants, the project would supply pellets at costs competitive with other worldwide suppliers.

During the year, Kaiser Steel Corp. shipped for the first time over 6 million tons of iron ore and pellets from its California Eagle Mountain mine. A total of 3.2 million tons, including 2 million tons of pellets, was exported to Japan, while 3 million tons including nearly 500,000 tons of pellets was shipped to its own facilities at Fontana, Calif.

USS constructed new ore washing facilities at its Sherman mine (Minnesota). The equipment was designed to improve the iron content and structure of iron concentrate.

Major alterations were scheduled for the National Steel pellet plant (Minnesota) of the Hanna Mining Co. To insure production of pellets, a new pelletizing section will be installed to match the 2.4-million-ton annual capacity of the present facility. The work was scheduled for completion early in 1969.

Iron ore pellet shipments in Minnesota continued to make news as Erie Mining Co. set a new record high of 10.7 million tons followed by Revere Mining Co. with 9.5 million tons. Near yearend, Eveleth Taconite Co. shipped its 5 millionth ton of pellets, of which 1.7 million tons was shipped in 1968.

Economics was the principal reason given by McLouth Steel Corp. for not developing its taconite ore deposits in Ashland County, Wis. Studies indicated that a pellet of desired quality could not be economically produced. Original research produced pellets too high in silica and too low in iron content. Improved processing techniques produced pellets of the desired quality, but plant costs were too high for economic development.

At yearend, construction was well underway at Black River Falls, Wis., for an iron ore concentrating and pelletizing plant for Jackson County Iron Co., a subsidiary of Inland Steel Co. The plant, to have an annual capacity of 750,000 tons, was scheduled for completion by late 1969.

CONSUMPTION AND USES

The method of reporting iron ore consumption adopted in 1963 was continued in 1968. Concentrate used for agglomerate produced at mine sites was not reported as iron ore consumption. Its consumption was reported when the agglomerate produced was shipped to the furnace site and used. However, concentrate and fines used for agglomerate production (mainly sinter) at blast furnaces and steel mills was reported as iron ore consumed. This method of reporting gives a valid balance between reported consumption and iron ore supply (production plus imports less exports including adjustments for losses due to processing and transporting).

Iron ore consumed in making agglomerate at steel mills includes foreign and domestic direct-shipping ores, fines generated in shipping, and foreign and domestic iron ore concentrate. Other materials such as limestone, flue dust, mill scale, and coke breeze used in making agglomerates was excluded.

Total consumption of iron ore and agglomerate is generally equivalent to total tonnage of steel production. For 1968, about 132 million tons was consumed, mainly in blast and steel furnaces. A minor quantity, 468,000 tons, was consumed in making paint, cement, and in production of ferroalloys. The consumption of iron ore for these minor uses was about the same as in 1967, whereas total consumption increased by over 4 million tons.

Although the consumption of agglomerate has remained relatively constant during the past 5 years, the direct consumption of iron ore in steel furnaces has steadily decreased, reflecting the increased percentage of steel produced in the basic oxygen furnace which does not use iron ore. At the same time, consumption of iron ore pellets increased from 22 million tons in 1964 to nearly 41 million tons in 1968.

STOCKS

Iron ore stocks at mines, U.S. docks, and consuming plants, excluding byproduct ore, totaled 72 million tons at yearend, about 1 million tons more than at yearend 1967. Mine stocks of 15 million tons increased about 3 million tons and were located mainly in the Lake Superior district, whereas stocks at consuming plants dropped 2 million tons and U.S. dock stocks were about equal to those of 1967.

Although steel production was at a record high, stocks of iron ore were maintained and represented a 7 months' supply at yearend.

PRICES

The average value of domestic usable ore per long ton f.o.b. mines, excluding byproduct ore, was $10.21, compared with $9.92 in 1967 and $9.49 in 1966. These data were taken from producers' statements and approximated the commercial selling price less the cost of mine-to-market transportation.

Published base prices for Lake Superior iron ores remained unchanged during 1968. The last price movement was in 1963 following a reduction in Great Lakes freight rates that was passed on to the purchaser. Late in the year, USS announced that its 1968 ore price schedule would prevail for 1969.

The 1968 quoted prices for Lake Superior ore, 51.5 percent iron, at rail of vessel, lower lake ports, per long ton were as follows: Mesabi nonBessemer, $10.55; Mesabi Bessemer, $10.70; Old Range non-Bessemer, $10.80; and Old Range Bessemer, $10.95. Corresponding base long ton unit values were $0.20485, $0.20777, $0.20971, and $0.21262, respectively. Lake Superior pellets were quoted at $0.252 per long ton unit; Marquette open-hearth lump, $12.60 per long ton; and Vermillion open-hearth lump, $13.15 per long ton.

Published minimum prices for selected foreign ores were as follows:

> Brazil—Run of mine (68–69 percent iron) f.o.b. Atlantic ports, $8.50 per long ton; lump, $10.40 per long ton.
>
> Sweden—Iron ore pellets (minimum 68 percent iron) f.o.b. Atlantic ports, $14.00 per long ton, nominal.
>
> Venezuela—Orinoco No. 1 (58 percent iron) f.o.b. Puerto Ordaz, $7.88 per natural long ton.

TRANSPORTATION

Early in the year, the National Transportation Safety Board recommended that Great Lakes bulk cargo ships either be strengthened at midship or to stay in port during major storms. The requirement was for vessels of over 400 feet in length and constructed of pre-1948 steel.

The St. Lawrence Seaway began its 10th season on April 10. Despite a 24-day workstoppage by members of the Canadian Brotherhood of Railway Transport and General Workers, over 21 million tons of iron ore was transported through the waterways and accounted for 32 percent of total traffic. A total of 17.9 million tons moved westbound through the Montreal-Lake Ontario section, of which 3 million tons were received by Canada. Iron ore moved both ways through the Wellington section and totaled 18.3 million tons. Of the total, 15.4

million tons moved westbound and 2.9 million tons was routed eastbound. Of the 2.9 million tons routed eastbound, 2.4 million tons originated in the United States.

In October 1967, the world's first long-distance slurry pipeline for transporting iron ore was placed in service by Savage River Mines (Australia). After operating for more than a year, the pipeline was reported to be an unqualified success with only some maintenance problems to be solved. In a related development, Marcona Corp. made initial trial shipments of iron ore slurry from Peru to Japan. The experience gained will be used to design a special iron ore slurry carrier. Plans call for delivery of slurry in a 40,000-ton carrier to supply the new prereduction plant of Oregon Steel Mill division of the Gilmore Steel Corp. (Oregon). Marcona will pump the slurry from the vessel using river water to assist in removing the slurry from the carrier.

Ground was broken for a new ship assembly facility at Erie, Pa., by Erie Marine Division of Litton Industries Inc. Construction was scheduled so that the first bulk ore carrier for Great Lakes service would be started by yearend. New concepts will be employed at the facility by introduction of production line techniques. Midsections of the vessels will be of modular construction and will be joined by an automatic welding process. Bow and stern sections will be subcontracted or built by Litton, whichever is more economical. This new approach to ore carrier construction was expected to result in substantial economies. It was expected that within 5 years, 15 to 20 of these new large lake carriers would be constructed.

Bethlehem Steel Corp. contracted with Litton for a 1,000-foot-long, self-unloading Great Lakes carrier designed to handle 51,500 tons of iron ore pellets. An advanced unloading system was specified which would be capable of discharging pellets at a rate of 20,000 tons per hour. The greatly reduced turnaround time and large tonnage to be handled should bring new economies to Great Lakes iron ore transportation. The vessel was scheduled for delivery in 1970.

An indication of the economic effect of large-sized vessels was made when Fuji Iron & Steel Co. Ltd. (Japan) and Cia. Vale do Rio Doce (Brazil) reached an agreement for future freight rates under their long-term contract for 50 million tons of iron ore negotiated in 1966. The original contract called for a freight rate of $7.34 per ton for shipment in 50,000-ton carriers. The new agreement calls for a reduction of $1.64 per ton for delivery in 90,000-ton carriers and $2.06 per ton for 105,000-ton carriers. The use of these larger sized carriers reduced shipping charges to under $0.50 per ton per thousand miles.

Owing to the trend in construction of larger size ore carriers and long-term Japanese ore contracts that call for improved port facilities, a number of port expansions were underway throughout the world. In addition to deepening channels and extending berthing length, material handling equipment was being improved to reduce turnaround time.

FOREIGN TRADE

Exports of iron ore were at the same rate as those of 1967 with most of the shipments going to Canada and Japan. Quantity of imports dropped slightly while value increased $0.38 per long ton compared with that of 1967. The higher value reflected increased shipments of iron ore pellets. Imports from Canada increased 2 million tons to partially offset a 2.5-million-ton decrease in Venezuelan shipments.

WORLD REVIEW

Algeria.—Algeria continued efforts to expand its share of the iron ore market. Agreements were made to export 600,000 tons to the U.S.S.R., 250,000 tons to Japan, and 300,000 tons to Rumania. The agreements included purchase of 40,000 tons of pipe from Japan, and assistance from the Soviets in the discovery and development of new mineral deposits.

Angola.—Iron ore production in Angola increased significantly owing to increased production at Companhia Mineira do Lobito's Cassinga mine. Production plans call for exports to increase to 5 million tons by 1970. Total ore reserve of the eluvial deposits, locally called "pebble ore," was estimated at over 70 million tons.

Iron ore deposits in the Cassala region, east of Luanda, was being investigated by Companhia do Manganese de Angola in conjunction with the Klöckner Werke A.G. steel firm in West Germany. Reserve of low-grade ore in the area was estimated at 500 million tons. If a feasibility study is implemented, an iron ore pellet plant with 1.5 million tons capacity would be constructed.

Australia.—Australia's iron ore mining industry continued to expand at a rapid rate. It was estimated that by 1975, Australia would be exporting 40 to 50 million tons per year, including nearly 35 to 40 percent of Japan's expected requirements.

Western Australia.—Initial operation of Broken Hill Pty. Co. Ltd.'s (BHP) new pellet plant at Whyalla occurred in May, while export of pellets to Japan began in October. Most of the planned output of 1.5 million tons of iron ore pellets was scheduled for export to Japan. A contract with Japanese steel mills called for delivery of almost 10 million tons from 1968–76.

After 3 years of negotiations, it appears that the Robe River iron ore deposit may be developed. Agreement was reportedly reached between Japanese steel interests and an Australian-United States group for the delivery of 4.2 million tons of pellets annually over a 21-year period. Negotiations on delivery of 2.6 million tons of crushed iron ore over a 15-year period continued.

Goldsworthy Mining Ltd. negotiated two contracts with Japanese steel mills for additional iron ore delivery. The larger contract calls for delivery of 10 million tons (5 million tons of lump ore and 5 million tons of fines) over a 10-year period. The other contract was for over 1 million tons per year of iron ore fines over a 5-year period. During its fiscal year 1967–68, Goldsworthy shipped in excess of 4 million tons to consumers. In September, an offer was made to Japanese steel mills for additional ore. If accepted, production would increase to 8 million tons during the next 5 years.

The year was one of expansion for Hamersley Iron Pty. Ltd. as shipments increased to 9.1 million tons from 5.2 million tons in 1967. An iron ore pellet plant with an annual capacity of 2 million tons started operation early in the year. An agreement was made with the state of Western Australia which increased Hamersley's ore reserves. The Paraburdao mining area with 300 million tons of high-grade hematite ore, proved by drilling, was acquired and in return Hamersley was required to produce metallized iron ore pellets at the rate of 1 million tons annually by 1971 and to initiate mining operations at Paraburdao. An agreement between Hanwright Iron Co. and the State of Western Australia was amended to allow Bruce Mountain Mining Pty. Ltd., (BMM) to acquire iron ore reserves held by Hanwright. BMM is 75 percent owned by Hammersley.

The Mount Newman joint venture project was proceeding on schedule for production of high-grade iron ore in 1969. Initial facilities were designed to produce 5 million tons annually with eventual expansion to a minimum of 20 million tons. Additional contracts were negotiated with Japanese steel mills for 46 million tons for long-term delivery. This increased the future total tonnage sold to Japanese mills to 146 million tons. In addition, 78 million tons of ore has been sold to BHP, bringing total sales to 216 million tons before the mine initiates operations.

Tasmania.—Savage River Mines brought into production facilities to produce 2.25 million tons of iron ore pellets. A novel feature of the facilities was the 53 mile pipeline through which iron ore concentrate was transported to the pellet plant site. Run-of-mine ore contains 38 percent iron which was beneficiated to 67-percent-iron concentrate.

Brazil.—Cia. Vale do Rio Doce (CVRD) negotiated a contract to supply Japanese steel mills 2.8 million tons of iron ore over an 8-year period beginning in 1971. The company plans to double production and exports by 1971 to 20 million tons annually, including 2 million tons of pellets from its plant at Tubarão which is scheduled for operation in 1969.

Major iron ore deposits discovered in the State of Pará by Cia. Meridional de Mineragão (CMM), a subsidiary of United States Steel Corp., are extremely large and will require time for complete exploration. Reportedly, CMM and CVRD will continue exploration, but commercial exploitation cannot be expected until 1975.

A Geological Survey professional paper, discussed the geology and iron deposits of western Serra do Curral, Minas Gerais, Brazil.[2] Total iron resources of the area include nearly 120 million tons of indicated and inferred reserves of high- and low-grade ore and more than 1,600 million tons of potential resources.

Canada.—Canadian iron ore shipments increased for the seventh consecutive year, reaching a record high of 44 million tons. Annual iron ore capacity was about 47 million tons at yearend, which includes over 25 million tons of iron ore pellet capacity.

A detailed survey of Canadian iron ore resources was carried out by the Geological Survey of Canada as part of the world survey of iron ore resources, sponsored by the United Nations. The study indicated that Canadian iron ore resources include 33 billion tons of ore reserves and 87 billion tons potential resource for a total resource of 120 billion tons of ore, ranging from 10 to 68 percent iron. Most of the ore reserve was located in the Labrador geosyncline region.

Ontario.—The Steel Company of Canada Ltd.'s Griffith mine, at Bruce Lake, initiated operations early in the year and was officially opened in June. The beneficiation plant with an annual capacity of 1.5 million tons per year treats run-of-mine ore grading 26 percent iron to produce 66 percent iron ore pellets. About 6 tons of ore was required for 1 ton of shippable pellets. Ore reserve was reportedly 25 to 30 years at capacity operation.

Falconbridge Nickel Mines Ltd. announced plans to construct a concentrator in the Sudbury area to produce 330,000 tons annually of iron ore pellets containing 90 percent iron and 1.5 percent nickel. The plant was scheduled for operation late in 1969.

The Sherman Mine, a joint venture owned by Dominion Foundries & Steel Ltd. and Tetapago Mining Co. Ltd., a wholly owned subsidiary of The Cleveland-Cliffs Mining Co. Ltd., was placed in operation early in 1968 and reached full capacity by midyear. The new concentrator and pellet plant treats low-grade crude iron ore averaging 24 percent magnetic iron in producing iron ore pellets containing 65 percent iron and 7 percent silica.

Quebec.—Iron Ore Company of Canada (IOC) completed an expansion of its Carol pellet plant and planned to expand its docking and loading facilities at Sept-Iles. The new dock will be capable of handling vessels up to 150,000 tons and will be able to load iron ore or pellets at 15,000 tons per hour. IOC, Canada's leading producer of iron ore, shipped a record 16.5 million tons of ore during the year, comprised of 9 million tons of iron ore pellets, 6.5 million tons of direct shipping ore, and about 0.9 million tons of concentrate.

Chile.—Bethlehem-Chile Iron Mines Company negotiated a contract for between 7.7 and 11.5 million tons of iron ore with Japanese steel firms. Delivery will be made over an 8-year period starting in 1971. Bethlehem planned to expand production at its El Romeral mine from 3 million tons per year to over 4 million tons per year by 1970.

Gabon.—Bethlehem Steel Corp. presented a proposal to Japanese steel companies for participation in an international syndicate to develop the Mekambo iron ore deposit. The syndicate has obtained the concession for development of the deposit from the Gabon Government. Bethlehem requested Japanese participation in the project on the condition that Japan share 10 percent of the development cost which will total $200 to $300 million.

Hungary.—A new concern, Borsod Ore Dressing Co., planned to begin operation of an iron ore beneficiation plant with an annual capacity of 1.5 million tons by yearend. The new plant is important to Hungary as 90 percent of its ore requirements are imported, mainly from the U.S.S.R. During 1968, imports from the U.S.S.R. were expected to total 2.5 million tons, rising to 3 million tons in 1970.

India.—The iron ore industry was India's third most important foreign exchange earner. Production totaled 27 million tons of which 15.4 million tons was for export and the balance for domestic iron and steel producers. High-grade iron ore reserve was estimated at 21 billion tons, recoverable by open-pit mining methods. Over 6 billion tons of iron ore was listed as measured or indicated, while nearly 15 billion tons was in the inferred category. The Government of India agreed to enter into a joint venture with United States and Japanese interests to study the feasibility of development of the Kudremukh iron ore deposits in the State of Mysore. If the deposit is economically exploitable, production of ore would initiate in 1974 or 1975 at a rate of 4 million tons of concentrate annually. Ore reserve was estimated at 1 billion tons of ore that could be beneficiated to a salable product.

---

[2] Simmons, George C. Geology and Iron Deposits of the Western Serra do Curral, Minas Gerais, Brazil. U.S. Geol. Survey Prof. Paper 341-G, 1968, 57 pp.

The Bailadila iron ore project in Madhya Pradesh was formally commissioned in November 1968. The project, which is the largest mechanized mine in India, was developed under an agreement between the Government of India and Japanese steel producers for an annual export of 4 million tons of iron ore to Japan. Shipments were made through the mechanized loading facilities at Visakhapatnam. The Government reportedly approved an expenditure of $41.3 million for an outer port expansion to accommodate 150,000-deadweight-ton ore carriers, with drafts of more than 50 feet. This would increase the port's iron ore export capacity from the present 3 million tons to approximately 10 million tons.

Japanese steelmakers contracted for 8.5 million tons of various Indian iron ore from India Minerals and Metals Trading Corp. Delivery was scheduled over a 3-year period.

Iran.—The U.S.S.R. was reported to have designed a mining complex for the Chogart area which will supply iron ore to a steel plant at Isfahan. The plant was scheduled for operation in 1971 with plans to increase ore production to 4 million tons per year. Ore reserve was estimated at 15 million tons for open-pit mining and 40 to 100 million tons by underground methods. The ore contains 58 to 62 percent iron.

Japan.—Japan continued its worldwide search for iron ore for its expanding steel industry. Contracts for long-term delivery were signed with a number of nations throughout the world. According to the Japanese Ministry of International Trade and Industry, to meet Japan's planned output of 80 million tons of raw steel by 1970 or 1971, 86 million tons of iron ore will have to be imported. Japan's consumption of iron ore during its fiscal year 1967–68 totaled 66 million tons.

Korea, North.—Japanese steelmakers contracted for 485,000 tons of iron ore from North Korean Fuels and Minerals Export and Imports Corp. Delivery was scheduled for 1968 with a price of $7.50 per ton f.o.b. for ore containing 59 percent iron.

Liberia.—During 1968, Liberian iron ore production totaled 19.3 million tons while exports for the year totaled 18.6 million tons. Production at Liberia Mining Co. Ltd. and National Iron Ore Co. Ltd. declined slightly from 1967 levels from 2.8 to 2.7 and from 3.6 to 3.3 million tons, respectively, while Bong Mining Co. and the Liberian-American-Swedish Minerals Co. (LAMCO) increased production over 1967 totals from 3.7 to 4.1 and from 8.0 to 8.9 million tons, respectively. LAMCO's production included 1.2 million tons of pellets which sold at more than $11 per ton. This price was in contrast to that paid for some grades of crude ore which sold at less than $7 per ton.

Bong Mining Co. carried out exploration of iron ore deposits in the Putu Range of southeastern Liberia while exploration of iron ore deposits in the Wologisi Range of northwestern Liberia was carried out by the Liberia Iron and Steel Corporation.

West Germany continued to be the leading importer of Liberian iron ore with imports of 6.0 million tons during 1968. Italy, with imports of 2.6 million tons, was the second largest purchaser of Liberian iron ore, slightly ahead of the United States which purchased 2.6 million tons.

Mauritania.—Société des Mines de Fer de Mauritanie (MIFERMA), one of the larger iron ore producers in Africa, continued its outstanding performance. The hematite ore, notable for its low sulfur and phosphorus content, was mined by open pit methods and transported 400 miles to the shipping dock at Port Etienne. Ore reserve of the main ore body was estimated at 200 million tons.

Mexico.—Plans continued for the exploitation of the Peña, Colorada iron ore deposits in the State of Colima. An iron ore pelletizing plant with an annual capacity of 1.2 million tons was under consideration. Ore reserve was estimated at over 100 million tons.

Cía. Cerro del Mercado S.A., a subsidiary of Cía. Fundidora de Fierro y Acero de Monterrey, S.A., started operations at its new heavy-media beneficiation plant.

The plant was expected to produce 800 tons per day of concentrate containing 62 percent iron.

Netherlands.—Four German steel firms, August Thyssen-Hütte A.G., Oberhausen, Krupp, and Mannesmann formed a corporation at Rotterdam to construct an ore terminal for transshipment of ore up the Rhine in barges. Facilities for unloading up to 50,000 tons per day will be available and ships of up to 150,000 tons deadweight will be accommodated.

New Zealand.—New Zealand Steel Ltd. continued construction of facilities to process iron-sands to steel by the use of a Stelco-Lurgi reduction kiln and an electric-arc steelmaking furnace. Operation was scheduled for April 1969. Iron-sand is titaniferous magnetite and concentrate of this material contains 60 percent iron and 7 to 8 percent titanium dioxide (TiO_2). The process calls for producing an iron-sand concentrate that is pelletized, with reduction of the pellets to sponge iron prior to making steel in the electric arc furnace. Capacity of the plant was reportedly 150,000 tons of steel annually.

Norway.—Construction was underway for a new iron ore pelletizing plant near the arctic circle by A/S Sydvaranger. Scheduled for completion in 1969, the 1.2-million-ton plant will increase iron ore production capacity to 3.4 million tons annually.

Portugal.—Lurgi Gesellschaft fur Chemie und Huttenwessen of Frankfort, a German firm holding a concession from the Portuguese Government to develop iron deposits in the Moncorvo iron field of northeast Portugal, announced plans for construction to start on an iron ore pellet plant in January 1969. Pilot-plant studies and economic evaluations were made by the firm to justified selling on the international market. The ore reserve was reported to contain 300 million tons.

Sierra Leone.—During the year, Sierra Leone Development Co. (DELCO) increased its shipments of iron ore to a record 2.5 million tons. DELCO concluded a long-term contract to supply iron ore concentrate from its Marampa mine to three Japanese steel mills. The contract covers shipments of 400,000 tons during 1968 and the first half of 1969; thereafter, shipments would be at an annual rate of 1.1 million tons for 10½ years. Under terms of the contract, the port of Pepel would be improved to handle ore carriers of 90,000-ton capacity.

South Africa, Republic of.—South African Iron and Steel Corp. (ISCOR) offered to supply 5 million tons of iron ore annually to Japan. At yearend, final arrangements were made to supply Japanese interests 1.2 million tons annually over a 3-year period, beginning in 1969.

Spain.—A new Government mining policy hopes to raise iron ore production from the 1967 level of 5 million tons to 13.4 million tons by 1973. Under the 5-year program, mining concerns that participate will receive credits as well as tax concessions.

Sweden.—Luossavaara-Kiirunavaara a.-b., the state-owned iron ore mining company, set a new record by shipping 25.5 million tons. The Grangesberg Co., the largest private concern, also set a new record high by shipping 3.6 million tons. Most of Sweden's production is exported to West Germany, Belgium-Luxembourg, and the United Kingdom. Considerable interest was shown in Grangeberg's new cold bonded iron pellets. The new pelletizing process uses finely ground cement clinker as the bonding agent for iron ore fines. A pellet plant under construction was expanded to 1.2-million-ton capacity.

U.S.S.R.—The British based Davy-Ashmore group secured a contract from the U.S.S.R. for a $10.2 million pelletizing plant to be erected in the Krivoi Rog ore field. Lurgi's process and designs will be used, with Ashmore manufacturing most of the equipment.

Venezuela.—The majority of Venezuela's iron ore production was essentially limited to two companies, the Orinoco Mining Co., (OMC), a subsidiary of USS, and Iron Mines Co. of Venezuela, C.A. (IMC), a subsidiary of Bethlehem Steel Corp. OMC exported 12.7 million tons during the year of which 7.7 million tons was received by the United States. IMC exported 2.9 million tons to Bethlehem's Sparrows Point, Md., plant.

OMC concluded agreements with the Venezulean Government to construct an iron ore beneficiation and pelletizing plant of 1-million-ton capacity in Ciudad Guayana. Initial construction of the plant began at midyear and will feature a fluidized-bed gaseous reduction of concentrate to produce an 86.5-percent iron product that will be briqueted. Construction plans call for plant operation in 1970.

Consideration was being given to the development of the San Isidro iron deposits which contain an estimated 350 million tons of high-grade iron ore. An international consortium of four companies signed a contract with the Government to determine the feasibility of producing 4.5 million tons of iron ore including 2.5 million tons of iron ore pellets.

TECHNOLOGY

Owing to the size of the iron ore industry, technologic advance moves slowly, although great strides have been made in recent years. Most of the technology has been directed at cost reduction as the industry has been faced with increasing worldwide competition. High-cost underground mines and marginal mines continued to phase out as the development of lower cost open-pit taconite-type deposits and worldwide high-grade iron ore deposits continued.

The technology of iron ore movement continued to advance. Larger iron ore carriers were either under construction or under contract, and even larger carriers were on the drawing boards. Ports were being deepened or plans for deepening were under consideration as some long-range contracts called for delivery of ore in large carriers. The dramatic growth in size of ocean ore bulk carriers during the past 15 to 20 years was expected to continue into the 1970's. In 1950, the largest ore carrier was Bethlehem Steel Corp.'s 24,500-ton *Venore*. During the past year, a 154,000-deadweight-ton carrier, for dry bulk service, was under construction and under consideration for the 1970's were carriers ranging up to 250,000 tons.

The technology of prereduced pellets continued to move ahead with announcements of new plants under construction. Midland-Ross Corp. will employ a gaseous reduction process to make 90 percent metallic iron pellets for Gilmore Steel Corp. (Oregon). Orinoco Mining Co. (Venezuela) planned to complete a plant in 1970 to produce 86.5 percent metallic iron briquets by the HIB process. New Zealand Steel Ltd.'s (New Zealand) plant will use a Stelco-Lurgi process to produce sponge iron from iron-sands. Hamersley Iron Pty. Ltd. (Australia) performed test work on a process similar to the Stelco-Lurgi process and was committed to build a 1-million-ton plant by 1970.

Highveld Steel and Vanadium Corp. (Republic of South Africa) brought into production facilities to produce steel by direct reduction of ore. The Highveld ore contains 56 percent iron, 13 percent titanium dioxide, and 1.5 to 1.9 percent vanadium pentoxide. At yearend, McWane Cast Iron Pipe Co. (Alabama) was in the final construction stages of a new plant to produce pig iron by utilizing the D–LM process for direct reduction of iron ore.

Conclusion of a long-term development program resulted in an announcement by Falconbridge Nickel Mines Ltd. (Canada) that construction of a plant to produce prereduced iron ore pellets from pyrrhotite would be started. The facility will have a capacity of 300,000 tons of iron ore pellets annually containing 90 percent iron and 1.5 percent nickel. Sulfur will be recovered at an adjacent plant operated by Allied Chemical Canada Ltd.

These various processes bring to a commercial-scale technology that has been developed over a period of years. Most of the plants were designed to treat a unique type of ore, or to serve a particular geographic area. For small integrated iron and steel plants, it appears that direct reduction of iron ore is economically feasible and the process may challenge blast furnaces in the future.

Mesabi semitaconite and oxidized taconite ores that cannot be concentrated by froth flotation can be rendered amenable to flotation through partial concentration in a high-intensity wet magnetic separator according to a study conducted by the Minnesota Mines Experiment Station.[3]

---

[3] Lawver, J. E., J. L. Wright, and H. R. Kokal. The Behavior of Mesabi Iron and Silicate Minerals in 20-Kilogauss Magnetic Fields. Trans. Soc. Min. Eng., v. 241, No. 2, June 1968, pp. 194–203.

A trilogy of Bureau research reports showed efforts made to obtain a wide knowledge of the problems encountered in melting titaniferous magnetites.[4] Using hot-stage microscope and melting-holding-quenching (strip furnace) techniques, slags with liquidus temperatures ranging from 1,217° to 1,900° C were studied with attempts being made to predict satisfactory slag compositions in smelting the magnetites to pig iron in an electric furnace.

The Bureau of Mines investigated the conversion of nonmagnetic iron minerals to magnetic form through reduction roasting operations.[5] Results of the study indicated that an iron concentrate of 66 percent iron with over 90-percent iron recovery could be achieved using a combination of crude siliceous iron ore, pyritic ore, and tailings.

Bureau researchers studied the softening characteristics of both unfired and indurated iron ore pellets as measured by hot compression strength.[6] The hot compressive strength of magnetite pellets when heated in air was far superior to similarly treated pellets made from hematite, specularite, or goethite. Magnetite pellets attained greater strengths in an oxidizing atmosphere than in neutral or reducing atmospheres. A conclusion of the investigation indicated that pellet makers are perhaps building more strength into pellets than is actually required.

As part of a broad investigation of metallurgical reactions in the iron ore blast furnace, the Bureau of Mines conducted a kinetic study of the carbon deposition reaction.[7] The disproportionation of carbon monoxide on iron ore pellets was investigated at pressures between 0.5 and 2 atmospheres and temperatures of 400° C to 1,075° C. The maximum rate for carbon deposition occurred at 550° C. The addition of 1 percent hydrogen increased the rate of carbon deposition about 100-fold.

Bureau scientists studied the kinetics of the initial reduction stages of magnetite in a hydrogen atmosphere.[8]

---

[4] Holmes, Wesley T. II, Lloyd H. Banning, and Lawrence L. Brown. Liquidus Temperatures of Titaniferous Slags (in Three Parts). 1. TiO_2–Al_2O_3–SiO_2–CaO–MgO. BuMines Rept. of Inv. 7081, 1968, 21 pp.

Holmes, Wesley T. II, Lloyd H. Banning, Lawrence L. Brown, and Gerald G. Thompson. Liquidus Temperatures of Titaniferous Slags (in Three Parts). 2. TiO_2–Al_2O_3–FeO–SiO_2–CaO–MgO. BuMines Rept. of Inv. 7083, 1968, 17 pp.

Holmes, Wesley T. II, and Williams A. Stickney. Liquidus Temperatures of Titaniferous Slags (in Three Parts). 3. Production of Nominal Slag Compositions. BuMines Rept. of Inv. 7232, 1969, 21 pp.

[5] Prasky, Charles, and Willard S. Swanson. Reduction Roasting of Steep Rock Iron-Bearing Materials. BuMines Rept. of Inv. 7242, 1968, 21 pp.

[6] Reuss, J. L., and M. M. Fine. Physical Properties of Iron Ore Pellets At Elevated Temperatures. BuMines Rept. of Inv. 7060, 1968, 24 pp.

[7] Haas, L. A., S. E. Khalafalla, and P. L. Weston, Jr. Kinetics of Formation of Carbon Dioxide and Carbon From Carbon Monoxide in Presence of Iron Pellets. BuMines Rept. of Inv. 7064, 1968, 29 pp.

[8] Rushton, T. N., and S. E. Khalafalla. Kinetics of the Initial Reduction Stages of Magnetite in Hydrogen. BuMines Rept. of Inv. 7080, 1968, 28 pp.

Table 2.—Employment at iron ore mines and beneficiating plants, quantity and tenor of ore produced and average output per man, by districts and States, in 1968

District and State	Employment p					Production p 1								
	Average number of men employed (thousands)	Time employed				Crude ore (thousand long tons)	Usable ore			Average per man				
		Average number of days	Total man shifts (thousands)	Man hours			(Thousand long tons)	Iron contained 2		Crude ore		Usable ore		
				Average per shift	Total (thousands)			(Thousand tons)	Percent (natural)	Per shift	Per hour	Per shift	Per hour	Iron contained
														Per shift	Per hour
Lake Superior:															
Minnesota	9	317	2,838	8.0	22,723	127,823	52,579	30,723	58.4	45.04	5.63	18.53	2.31	10.83	1.35
Michigan	3	299	1,011	8.0	8,086	29,218	13,770	8,455	61.4	28.90	3.61	13.62	1.70	8.36	1.05
Total	12	313	3,849	8.0	30,809	157,041	66,349	39,178	59.0	40.80	5.10	17.24	2.15	10.18	1.27
Southeastern States:															
Alabama and Georgia	1	254	134	8.6	1,151	3,059	1,509	606	40.2	22.83	2.66	11.26	1.31	4.52	.53
Northeastern States:															
New York, Pennsylvania	2	285	577	8.3	4,625	10,075	3,963	2,506	63.3	17.46	2.18	6.87	.86	4.34	.54
Western States:															
Montana, Utah, Wyoming	1	294	281	8.0	2,252	8,210	3,827	1,792	46.8	29.22	3.65	13.62	1.70	6.38	.80
Undistributed 3	3	267	702	8.0	5,615	17,990	9,614	5,880	61.2	25.63	3.20	13.70	1.71	8.38	1.05
Grand total	18	300	5,543	8.0	44,452	196,375	85,262	49,962	58.6	35.43	4.42	15.38	1.92	9.01	1.12

p Preliminary.

[1] Includes manganese bearing ore in the Lake Superior District.

[2] Average content of all types of ore shipped.

[3] Includes Arizona, California, Colorado, Idaho, Missouri, Nevada, New Mexico, and Texas.

Table 3.—Crude iron ore mined in the United States, by districts, States, and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1967					1968				
	Number of mines	Hematite	Brown ore	Magnetite	Total	Number of mines	Hematite	Brown ore	Magnetite	Total [1]
Lake Superior:										
Michigan	15	W	---------	W	28,638	11	W	---------	W	29,218
Minnesota	45	48,948	83	67,120	116,151	50	37,012	60	90,308	127,380
Total	60	48,948	83	67,120	144,789	61	37,012	60	90,308	156,598
Southeastern States:										
Alabama	15	1,036	2,638	---------	3,674	7	1,078	1,251	---------	2,329
Georgia	11	---------	1,046	---------	1,046	3	---------	730	---------	730
Total	26	1,036	3,684	---------	4,720	10	1,078	1,981	---------	3,059
Northeastern States: New York, Pennsylvania	7	---------	---------	10,329	10,329	5	---------	---------	10,075	10,075
Western States:										
Arizona	3	W	---------	W	W	3	W	---------	W	17
California	3	W	---------	W	W	3	W	---------	W	W
Colorado	2	---------	W	W	W	3	---------	W	W	197
Idaho	2	---------	---------	W	W	2	---------	---------	W	W
Mississippi	1	---------	W	---------	W	---------	---------	---------	---------	---------
Missouri	3	---------	W	W	2,390	2	---------	---------	W	W
Montana	2	---------	---------	11	11	2	---------	---------	12	12
Nevada	4	W	---------	W	W	4	W	---------	W	W
New Mexico	2	W	---------	W	W	3	---------	---------	W	W
Texas	6	---------	W	---------	W	3	---------	[2] W	---------	W
Utah	5	W	---------	W	1,912	6	W	---------	W	4,016
Wyoming	5	W	---------	W	4,136	4	W	---------	W	4,182
Total	38	W	W	11	8,449	33	W	W	12	8,424
Undistributed:	-------	20,152	2,622	29,412	15,110	---------	20,060	[2] 2,093	33,251	17,776
Grand total [1]	131	70,136	6,389	106,872	183,397	109	58,150	[2] 4,134	133,646	195,932

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Data may not add to totals shown because of independent rounding.

[2] Includes a small quantity of carbonate.

Table 4.—Crude iron mined in the United States, by districts, States, and mining methods

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1967			1968		
	Open pit	Underground	Total	Open pit	Underground	Total
Lake Superior:						
Michigan	23,456	5,182	28,638	24,574	4,644	29,218
Minnesota	115,750	401	116,151	127,380	---------	127,380
Total	139,206	5,583	144,789	151,954	4,644	156,598
Southeastern States:						
Alabama	2,638	1,036	3,674	1,251	1,078	2,329
Georgia	1,046	---------	1,046	730	---------	730
Total	3,684	1,036	4,720	1,981	1,078	3,059
Northeastern States: New York, Pennsylvania	W	W	10,329	W	W	10,075
Western States:						
Arizona	W	---------	W	17	---------	17
California	W	---------	W	W	---------	W
Colorado	W	---------	W	197	---------	197
Idaho	W	---------	W	W	---------	W
Mississippi	W	---------	W	---------	---------	---------
Missouri	W	W	2,390	---------	W	W
Montana	11	---------	11	12	---------	12
Nevada	W	---------	W	W	---------	W
New Mexico	W	---------	W	W	---------	W
Texas	W	---------	W	W	---------	W
Utah	1,912	---------	1,912	4,016	---------	4,016
Wyoming	W	W	4,136	W	W	4,182
Total	1,923	W	8,449	4,242	W	8,424
Undistributed:	24,769	7,196	15,110	25,052	6,981	17,776
Grand total	169,582	13,815	183,397	183,229	12,703	195,932

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

Table 5.—Crude iron ore shipped from mines in the United States, by districts, States, and disposition

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1967			1968		
	Direct to consumers	To beneficiation plants	Total	Direct to consumers	To beneficiation plants	Total [1]
Lake Superior:						
Michigan	3,011	25,692	28,703	2,353	26,650	29,003
Minnesota	11,149	104,583	115,732	5,044	121,904	126,947
Total	14,160	130,275	144,435	7,397	148,553	155,950
Southeastern States:						
Alabama	201	3,402	3,603	148	2,006	2,154
Georgia	---------	1,046	1,046	---------	730	730
Total	201	4,448	4,649	148	2,736	2,884
Northeastern States: New York, Pennsylvania	-------	10,331	10,331	---------	10,014	10,014
Western States:						
Arizona	W	---------	W	W	---------	W
California	W	W	W	W	W	W
Colorado	W	---------	W	W	---------	W
Idaho	W	---------	W	W	---------	W
Mississippi	-------	W	W	---------	---------	---------
Missouri	-------	2,443	2,443	---------	W	W
Montana	10	---------	10	12	---------	12
Nevada	W	W	W	W	W	W
New Mexico	W	W	W	---------	W	W
Texas	-------	W	W	---------	W	W
Utah	W	W	1,888	W	W	2,044
Wyoming	W	W	4,153	W	W	4,146
Total	10	2,443	8,494	12	W	6,202
Undistributed:	1,800	19,483	15,242	1,768	22,331	17,909
Grand total	16,171	166,980	183,151	9,325	183,634	192,959

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Data may not add to totals shown because of independent rounding.

Table 6.—Usable iron ore produced in the United States, by districts, States and varieties

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1967 Hematite	1967 Brown ore	1967 Magnetite	1967 Total	1968 Hematite	1968 Brown ore	1968 Magnetite	1968 Total
Lake Superior:								
Michigan	W	------	W	14,072	W	------	W	13,770
Minnesota	27,924	58	22,175	50,157	22,116	83	30,255	52,454
Total	27,924	58	22,175	64,229	22,116	83	30,255	66,224
Southeastern States:								
Alabama	877	751	------	1,628	914	411	------	1,326
Georgia	------	261	------	261	------	183	------	183
Total	877	1,012	------	1,889	914	594	------	1,509
Northeastern States: New York, Pennsylvania, Virginia	------	------	4,197	4,197	------	------	3,963	3,963
Western States:								
Arizona	W	------	W	W	W	------	W	W
California	W	------	W	W	W	------	W	W
Colorado	------	W	W	W	------	W	W	W
Idaho	------	------	W	W	------	------	W	W
Mississippi	------	W	------	W	------	------	------	------
Missouri	------	W	W	1,802	------	------	W	W
Montana	------	------	11	11	------	------	12	12
Nevada	W	------	W	W	W	------	W	W
New Mexico	W	------	W	W	------	------	W	W
Texas	------	W	------	W	------	W	------	W
Utah	W	------	W	1,708	W	------	W	1,818
Wyoming	W	------	W	1,837	W	------	W	2,002
Total	W	W	11	5,358	W	W	12	3,827
Undistributed	12,190	690	14,273	7,734	11,597	501	15,101	9,614
Total all States	40,991	1,760	40,656	83,407	34,627	1,177	49,331	85,137
Byproduct ore [1]	------	------	------	772	------	------	------	728
Grand total	40,991	1,760	40,656	84,179	34,627	[2] 1,177	49,331	85,865

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Data may not add to totals shown because of independent rounding.

[2] Cinder and sinter obtained from treating pyrites. Ore was treated in Arizona, Colorado, Delaware, Pennsylvania, Tennessee, and Virginia.

[3] Includes a small quantity of carbonate.

Table 7.—Usable iron ore produced in the United States, by districts, States, and types of products

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

District and State	1967				1968			
	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)	Direct shipping ore	Agglomerates	Concentrates	Iron content (natural percent)
Lake Superior:								
Michigan	3,007	10,588	477	60	2,440	10,772	557	60
Minnesota	11,111	24,327	14,719	57	5,002	30,255	17,197	58
Total	14,118	34,915	15,196	58	7,442	41,027	17,754	59
Southeastern States:								
Alabama	273	------	1,355	40	323	------	1,003	39
Georgia	------	------	261	45	------	------	183	48
Total	273	------	1,616	41	323	------	1,186	40
Northeastern States: New York, Pennsylvania, Virginia	------	W	W	W	------	W	W	W
Western States:								
Arizona	W	------	------	W	W	------	------	W
California	W	W	W	W	W	W	W	W
Colorado	W	------	------	W	W	------	------	W
Idaho	W	------	------	W	W	------	------	W
Mississippi	------	------	W	W	------	------	------	------
Missouri	------	1,791	11	68	------	W	W	W
Montana	11	------	------	45	12	------	------	45
Nevada	W	------	W	W	W	------	W	W
New Mexico	W	------	W	W	------	------	17	58
Texas	------	W	W	W	------	W	W	W
Utah	W	------	W	W	1,258	------	555	53
Wyoming	W	W	W	W	W	W	W	W
Total	11	1,791	11	68	1,270	W	572	45
Undistributed	1,796	7,632	6,047	59	530	9,350	5,682	58
Total All States [1]	16,198	44,338	22,871	58	9,565	50,377	25,194	58
Byproduct ore [2]	------	772	------	68	------	728	------	67
Grand Total [1]	16,198	45,110	22,871	58	9,565	51,105	25,194	59

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Data may not add to totals shown because of independent rounding.

[2] Cinder and sinter obtained from treating pyrites.

Table 8.—Shipments of usable iron ore from mines in the United States in 1968

(Thousand long tons and thousand dollars; exclusive of ore containing 5 percent or more manganese)

District and State	Gross weight of ore shipped				Iron content of ore shipped				
	Direct shipping ore	Agglomerates	Concentrates	Total quantity	Direct shipping ore	Agglomerates	Concentrates	Total quantity	Total value
Lake Superior:									
Michigan	2,353	9,786	560	12,699	1,572	6,069	158	7,799	148,890
Minnesota	5,044	29,751	16,480	51,275	2,700	18,451	8,822	29,973	508,814
Total	7,397	39,537	17,040	63,974	4,272	24,520	8,980	37,772	657,704
Southeastern States:									
Alabama	148	------	1,003	1,151	50	------	399	449	6,780
Georgia	------	------	192	192	------	------	94	94	1,119
Total	148	------	1,195	1,343	50	------	493	543	7,849
Northeastern States:									
New York, Pennsylvania, Virginia	------	W	W	3,549	------	W	W	2,246	50,648
Western States:									
Arizona	16	------	------	16	10	------	------	10	124
California	W	W	W	W	W	W	W	W	W
Colorado	W	------	------	W	W	------	------	W	W
Idaho	W	------	------	W	W	------	------	W	W
Missouri	------	W	W	1,648	------	W	W	1,099	23,585
Montana	12	------	------	12	5	------	------	5	W
Nevada	W	------	W	569	W	------	W	W	2,917
New Mexico	------	------	17	17	------	------	10	10	113
Texas	------	W	W	W	------	W	W	W	W
Utah	1,275	------	489	1,764	681	------	261	942	11,281
Wyoming	W	W	W	1,967	W	W	W	804	19,452
Total	1,303	W	506	5,993	696	W	271	2,870	57,472
Undistributed	478	9,116	5,215	7,076	272	5,413	3,032	4,568	62,767
Total all States [1]	9,326	48,653	23,956	81,934	5,290	29,933	12,776	47,999	836,433
Byproduct ore [2]	------	------	596	596	------	------	484	484	6,375
Grand total [1]	9,326	48,653	24,552	82,531	5,290	29,933	13,260	48,483	842,808

W Withheld to avoid disclosing individual company confidential data, included with "Undistributed."

[1] Data may not add to totals shown because of independent rounding.

[2] Cinder and sinter obtained from treating pyrites. Ore treated in Arizona, Colorado, Delaware, Pennsylvania, Tennessee, and Virginia.

Table 9.—Iron ore produced in the Lake Superior district, by ranges

(Thousand long tons and exclusive after 1905 of ore containing 5 percent or more manganese)

Year	Marquette	Menominee	Gogebic	Vermilion	Mesabi	Cuyuna	Spring Valley	Total [1]
1854–1963	322,910	279,033	317,760	100,975	2,415,868	66,155	6,191	3,508,891
1964	7,898	4,551	1,602	865	47,256	513	420	63,106
1965	8,973	4,595	810	782	50,280	367	625	66,432
1966	9,589	4,620	113	704	51,506	1,299	772	68,603
1967	10,231	3,792	49	202	48,857	1,041	58	64,229
1968	10,086	3,684	-------	-------	51,411	961	83	66,224
Total [1]	369,687	300,275	320,334	103,528	2,665,178	70,336	8,149	3,837,485

[1] Data may not add to totals shown because of independent rounding.

Table 10.—Average analyses of total tonnage (bill-of-lading weights) of all grades of iron ore from all ranges of Lake Superior district

Year	Thousand long tons	Content, percent [1]					
		Iron	Phosphorus	Silica	Manganese	Alumina	Moisture
1964	64,222	56.68	0.073	8.14	0.46	1.09	6.16
1965	64,689	56.85	.068	8.16	.48	1.00	6.10
1966	69,724	56.83	.068	7.99	.55	1.02	6.21
1967	63,845	57.81	.059	7.62	.47	.93	5.70
1968	64,065	58.70	.051	7.35	.40	.80	5.16

[1] Iron on natural basis; phosphorus, silica, manganese, and alumina on dried basis.

Source: American Iron Ore Association.

Table 11.—Consumption of iron ore and agglomerates in the United States in 1968

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

State	Iron ore [1]		Agglomerates [2]		Miscellaneous [3]	Total
	Blast furnaces	Steel furnaces	Blast furnaces	Steel furnaces		
Alabama, Kentucky, Tennessee, Texas	6,419	155	4,515	W	122	11,211
California, Colorado, Utah	4,737	438	2,636	---------	74	7,885
Maryland and West Virginia	3,031	300	8,165	W	W	11,496
Illinois and Indiana	15,815	857	11,909	W	W	28,581
Michigan and Minnesota	6,770	106	3,562	W	44	10,482
New York, Ohio, Pennsylvania, New Jersey	37,405	1,596	22,310	W	97	61,408
Undistributed	-------	---------	---------	560	132	692
Total [4]	74,176	3,452	53,097	560	468	131,753

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes 40,995,000 million tons of pellets and nodules produced at mines.

[2] Does not include agglomerate produced at mine site.

[3] Includes iron ore used in making paint and cement, also ore consumed in ferroalloy furnaces.

[4] Data may not add to totals shown because of independent rounding.

Table 12.—Beneficiated iron ore shipped from mines in the United States[1]

(Thousand long tons and exclusive of ore containing 5 percent or more manganese)

Year	Beneficiated	Total	Proportion of beneficiated to total (percent)
1964	64,329	84,300	76.3
1965	64,667	84,073	76.9
1966	70,451	90,041	78.2
1967	66,243	82,415	80.3
1968	72,781	81,934	88.8

[1] Excludes byproduct ore.

Table 13.—Usable iron ore[1] consumed in agglomerating plants and agglomerate produced from this ore in 1968, by States

(Thousand long tons)

State	Iron ore [1] consumed	Agglomerate produced
Alabama, Kentucky, Texas	3,047	3,584
California, Colorado, Utah	1,975	2,623
Maryland and West Virginia	5,321	5,553
Illinois, Indiana, Michigan	9,188	12,101
New York, Ohio, Pennsylvania	10,312	17,864
Total [2]	29,842	41,725

[1] Does not include material used in agglomerate produced at mine site.

[2] Data may not add to totals shown because of independent rounding.

Table 14.—Production of agglomerates[1] in the United States, by types

(Thousand long tons)

Type	Agglomerate produced	
	1967	1968
Sinter, nodules and cinder	[2] 45,995	43,605
Pellets	41,972	48,526
Total	87,967	92,131

[1] Production at mines and consuming plants.

[2] Includes 18,710 thousand tons of self-fluxing sinter.

Table 15.—Stocks of usable iron ore at mines[1] December 31, by districts

(Thousand long tons)

District	1967	1968
Lake Superior	r 8,253	10,503
Southeastern States	454	605
Northeastern States	3,359	3,775
Western States	r 893	1,107
Total	r 12,959	15,990

r Revised.

[1] Excluding byproduct ore.

Table 16.—Average value of usable iron ore shipped from mines or beneficiating plants in the United States in 1968

(Per long ton)

District	Direct-shipping ore			Concentrates			Agglomerates
	Hematite	Brown ore	Magnetite	Hematite	Brown ore	Magnetite	
Lake Superior	$6.89	------	------	$7.41	W	------	$12.16
Southeastern	W	------	------	W	$5.94	------	------
Northeastern	----	------	------	------	------	W	14.44
Western	5.75	$6.72	$6.44	6.33	W	$7.23	11.84
Total	6.77	6.72	6.44	7.33	8.05	7.30	12.28

W Withheld to avoid disclosing individual company confidential data.

Table 17.—U.S. exports of iron ore, by countries

(Thousand long tons and thousand dollars)

Destination	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	3,911	$48,567	2,258	$29,069	2,278	$28,113
Germany, West	62	382	43	270	53	349
Japan	3,778	42,876	r 3,602	42,179	3,550	42,314
Other countries	28	332	3	67	3	59
Total	7,779	92,157	r 5,906	71,585	5,884	70,835

r Revised.

Table 18.—U.S. imports for consumption of iron ore, by countries

(Thousand long tons and thousand dollars)

Country	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Australia	10	$101	1	$18	131	$1,384
Brazil	2,723	26,695	[r] 1,624	[r] 14,744	1,257	11,622
Canada	28,941	273,309	24,214	276,597	26,339	308,014
Chile	2,268	19,810	1,365	11,286	1,441	11,515
Liberia	3,390	24,851	3,099	23,737	2,942	23,389
Mauritania	107	1,563	24	302	---------	---------
Norway	41	369	436	2,217	360	2,646
Peru	1,043	11,281	879	9,404	925	9,375
Sweden	82	1,523	148	1,840	232	2,610
Venezuela	12,592	102,040	12,820	103,718	10,313	83,153
Other	62	812	1	55	1	45
Total	46,259	462,354	[r] 44,611	[r] 443,918	43,941	453,753

[r] Revised.

Table 19.—U.S. imports for consumption of iron ore, by customs districts

(Thousand long tons and thousand dollars)

Customs district	1967		1968	
	Quantity	Value	Quantity	Value
Baltimore	9,008	$84,192	9,261	$90,389
Bridgeport	---------	---------	4	45
Buffalo	2,460	32,842	2,546	32,735
Chicago	6,287	72,435	6,724	78,919
Cleveland	7,344	76,330	8,796	94,873
Detroit	1,693	24,590	1,381	20,071
Houston	438	5,421	775	8,981
Laredo	---------	---------	3	43
Los Angeles	---------	---------	33	231
Mobile	4,056	34,947	3,943	34,309
New Orleans	612	5,412	647	5,670
Norfolk	[r] 220	[r] 2,009	306	2,887
Ogdensburg	(1)	2	52	859
Pembina	---------	---------	24	347
Philadelphia	12,466	105,495	9,445	83,371
Savannah	24	210	---------	---------
Other	3	33	1	23
Total	[r] 44,611	[r] 443,918	43,941	453,753

[r] Revised.

[1] Less than ½ unit.

Table 20.—World production of iron ore, iron ore concentrates, and iron ore agglomerates, by countries[1]

(Thousand long tons)

Country	1964	1965	1966	1967	1968 p
North America:					
Canada	34,219	35,678	r 36,331	r 37,837	44,084
Mexico (60 percent Fe equivalent)	2,284	2,618	2,271	2,653	3,151
United States[2]	84,836	87,439	90,147	84,179	85,865
South America:					
Argentina	93	114	152	220	NA
Brazil	16,694	r 20,426	22,887	23,129	e 24,800
Chile	9,697	11,953	12,019	10,851	11,729
Colombia	699	695	652	795	1,058
Peru	6,425	6,992	7,664	7,538	8,409
Venezuela	15,409	17,234	17,479	16,854	15,934
Europe:					
Albania[2]	345	r 390	r 390	r 399	e 400
Austria	3,507	3,480	3,420	3,418	3,418
Belgium	60	90	122	e 90	e 90
Bulgaria	705	1,773	2,567	e 2,660	e 2,700
Czechoslovakia	2,801	2,407	r 2,191	r 1,884	1,516
Denmark	89	64	54	56	e 55
Finland[3]	466	r 871	r 947	638	e 850
France	59,976	58,592	54,191	48,443	54,427
Germany:					
East	1,608	1,604	1,694	r 1,653	e 1,450
West	11,430	10,676	9,318	8,418	7,592
Greece	---------	6	r 26	17	12
Hungary	763	750	735	r 955	864
Italy[3]	r 961	r 1,068	1,159	1,068	e 1,080
Luxembourg	6,575	6,215	6,425	r 6,204	6,297
Norway	2,089	2,425	r 2,412	3,181	3,641
Poland	2,638	2,817	3,006	r 3,026	3,002
Portugal	212	208	189	194	e 200
Rumania	1,901	2,440	2,639	2,752	2,524
Spain	5,026	5,601	4,989	5,005	6,087
Sweden	26,199	r 28,890	r 27,545	27,824	31,822
Switzerland	89	111	65	4	---------
U.S.S.R.	143,285	151,009	157,740	r 165,543	174,204
United Kingdom	16,326	15,415	13,658	12,740	13,728
Yugoslavia	2,271	2,464	2,454	2,539	2,677
Africa:					
Algeria	2,696	3,083	r 1,734	r 2,529	e 2,700
Angola	885	802	779	1,136	3,167
Guinea, Republic of	894	743	e 1,575	---------	---------
Liberia	12,794	15,707	16,593	17,936	19,262
Mauritania	5,000	6,185	7,044	7,334	7,400
Morocco	874	936	1,001	870	796
Rhodesia, Southern	811	e 1,340	r 1,280	NA	NA
Sierra Leone	1,962	2,110	2,268	2,065	2,953
South Africa, Republic of	r 5,600	r 6,617	r 7,570	7,615	8,103
South-West Africa, Territory of	9	32	37	e 37	NA
Sudan	(4)	34	38	14	NA
Swaziland	59	1,004	1,566	1,715	2,018
Tunisia	924	1,099	1,267	904	1,000
United Arab Republic	440	499	r 433	r 433	440
Asia:					
China, mainland e [5]	36,400	38,400	39,400	27,500	37,400
Hong Kong	114	132	135	142	159
India[6]	r 21,384	r 23,454	25,920	25,744	27,000
Iran[7]	r 2	r 2	r 3	r 3	e 3
Japan[8]	2,517	2,470	2,338	2,184	2,137
Korea:					
North e	r 4,800	5,800	5,900	6,400	6,900
South	674	723	777	687	817
Malaysia	6,465	6,873	5,763	5,350	5,085
Philippines	1,345	1,415	r 1,452	r 1,455	1,332
Thailand	188	738	681	540	492
Turkey	961	1,506	1,594	1,462	1,958
Oceania:					
Australia	5,668	6,696	r 10,893	18,517	25,983
New Caledonia	302	275	217	201	169
New Zealand	3	2	3	3	3
Total[9]	r 573,449	r 611,187	r 625,799	r 615,538	670,943

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Table does not include Guatemala or Uruguay, where iron-bearing materials are produced for manufacture of cement and other materials, or Pakistan, where production is for exploration or metallurgical testing.

[2] Iron-nickel ore.

[3] Includes pelletized iron oxide derived from pyrite.

[4] Less than ½ unit.

[5] Roughly, containing 50 percent iron.

[6] Including production from Goa, as follows: 1964, 6,052; 1965, 6,584; 1966, 6,534; 1967, 7,200; and 1968, 6,856.

[7] Year ending March 20 of following year.

[8] Including production from iron sands, as follows: 1964, 1,425; 1965, 1,391; 1966, 1,289; 1967, 1,126; and 1968, 1,114.

[9] Total is of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/74

Iron and Steel

By John W. Thatcher [1]

The apparent domestic consumption of steel mill products in 1968 rose to an all-time annual record of 107.7 million tons, surpassing the previous high level of 100.5 million tons consumed in 1965. The new record includes 18 million tons of imported steel mill products in addition to 91.9 million tons of domestic mill shipments with a deduction of 2.2 million tons for exports of steel. The record domestic demand reflected a marked increase in automobile production and moderate advances in container and machinery production and in construction activity.

The labor negotiation had a greater effect on the scheduling and size of steel production than any other single economic factor in 1968. Strike-hedge buying during the first half of 1968 resulted in a record steel output rate during the first 7 months of the year, which reached a peak rate of 415,000 tons per day in April. Following the signing of the labor contract on August 1, production fell off sharply but picked up again in the final quarter as inventories were worked off.

Table 1.—Salient iron and steel statistics

(Thousand short tons)

	1964	1965	1966	1967	1968
United States:					
Pig iron:					
Production	85,458	88,207	91,287	86,799	88,767
Shipments	85,693	88,391	90,884	86,819	89,085
Exports	176	28	12	7	9
Imports for consumption	736	882	1,187	605	786
Steel:[1]					
Production of ingots and castings (all grades):					
Carbon	114,442	116,651	118,732	113,190	116,269
Stainless	1,443	1,493	1,651	1,451	1,432
All other alloy	11,191	13,318	13,718	12,572	13,761
Total	127,076	131,462	134,101	127,213	131,462
Index (1957–59) = 100	130.5	135.3	138.1	131.0	135.0
Total shipments of steel mill products	84,945	92,666	89,995	83,897	91,856
Exports of major iron and steel products	4,065	2,888	2,144	1,898	2,460
Imports of major iron and steel products [2]	6,630	10,640	11,043	11,446	17,894
World production:					
Pig iron [3]	349,000	369,000	382,000	393,000	425,000
Steel ingots and castings	482,000	506,000	524,000	543,000	582,000

[1] American Iron and Steel Institute.
[2] Data not comparable for all years.
[3] Includes ferroalloys.

PRODUCTION AND SHIPMENTS OF PIG IRON

Total domestic production of pig iron increased 2 percent over that for 1967 and was exceeded only by the high level of production in 1966, a record steel-producing year. Pig iron shipments increased 3 percent over those for 1967 as new basic oxygen furnaces increased the demand for hot metal.

Domestic production of pig iron during the first 7 months of the year was sustained at the highest rate in the history of the industry, averaging over 8 million tons per month. Peak production occurred in April, when the average daily production exceeded 285,000 tons. Of the three largest producing States, Pennsylvania and Indiana about maintained their share of total domestic production while that portion contributed by Ohio increased by 1 percent over that for 1967 and accounted for most of the 2-million-ton increase in total domestic output in 1968. Production in Illinois decreased, due in part to a blast furnace failure coupled with a 53-day strike of blast furnace workers at one steel plant.

---

[1] Physical scientist, Division of Mineral Studies.

According to the American Iron and Steel Institute (AISI), there were 150 blast furnaces in blast on January 1, 1969, out of a total population of 224 furnaces. On the same day in 1968, there were 168 furnaces in blast out of a total of 223 furnaces. Continuing a trend begun after World War II, average production per blast furnace day increased 3 percent to 1,625 tons.

Metalliferous Materials Consumed in Blast Furnaces.—The agglomerate charge consisted of 29.0 million tons of sinter, 19.4 million tons of self-fluxing sinter, 45.5 million tons of pellets, and 10.9 million tons of foreign agglomerates. No consumption of unclassified agglomerates or nodules was reported.

According to AISI, blast furnace consumption of oxygen decreased 23 percent to 6.7 billion cubic feet in 1968. Data collected by the Bureau of Mines showed that 41.7 billion cubic feet of natural gas, 10.4 billion cubic feet of coke-oven gas, and 63.0 million gallons of oil were consumed by blast furnaces in 1968.

PRODUCTION AND SHIPMENTS OF STEEL

The upswing in the rate of raw steel production, which began late in 1967 under the impetus of strike-hedge buying, continued during the first 7 months of 1968, reaching a record peak in April of 415,000 tons per day. Following the signing of a basic steel labor contract on August 1, production fell off sharply for 2 months but picked up again in the final quarter as inventories of steel mill products were worked off faster than anticipated. Total raw steel production in 1968, 131.5 million short tons, was 3 percent higher than that for 1967 and was exceeded only by production in 1965 and 1966.

Of the total steel produced, open-hearth furnaces accounted for 50.1 percent; basic oxygen converters, 37.1 percent; and electric furnaces 12.8 percent. Comparable data for 1967 were 55.5 percent, 32.6 percent, and 11.9 percent, respectively. The rapid decline in the use of open-hearth furnaces was slowed somewhat by the reactivation of some open-hearths to meet the strong surge in demand for steel in the first 7 months of the year. Production of steel by the basic oxygen process increased 7.4 million tons or 18 percent in 1968 as new plants were started up by Alan Wood Steel Co., Crucible Steel Division of Colt Industries, Bethlehem Steel Corp., and Jones & Laughlin Steel Corp. The rate of growth of electric furnace steel, relatively small but steady in the last decade, is expected to increase in the next few years.

The market for domestic steel staged a strong comeback in 1968 despite a second half slowdown and competition from a record volume of imports. Net shipments of steel products, including exports, increased 8 million tons or more than 9 percent over those for 1967. A 20-percent increase in vehicle production resulted in a 2.8-million-ton increase in steel shipments to this market. Substantial increases in steel shipments to the construction industry, the container industry, the machinery industry, and steel service centers were also noted.

Alloy Steel.[2]—The production of full alloy steels increased 7 percent to 8.8 million tons in 1968, but fell below the record levels of 1965 and 1966. Production was higher in the chromium and molybdenum grades, reflecting an increased demand for hard, heat and corrosion-resistant steels. Shipments increased 7 percent to 5 million tons, reversing the downward fluctuation of 1966 and 1967. Hot rolled bars (including light shapes) accounted for 41 percent of the product mix while the automotive industry accounted for 29 percent of the market.

---

[2] The Bureau of Mines uses the American Iron and Steel Institute specifications for alloy steels, which include stainless and any other steel containing one or more of the following elements in the designated percentages: Manganese in excess of 1.65 percent, silicon in excess of 0.60 percent, and copper in excess of 0.60 percent. The specifications also include steel containing the following elements in any quantity specified or known to have been added to obtain a desired alloying effect: Aluminum, boron, chromium, cobalt, columbium, molybdenum, nickel, titanium, tungsten, vanadium, zirconium, and other alloying elements.

Stainless steel includes all grades of steel that contain 10 percent or more of chromium with or without other alloys or a minimum combined content of 18 percent of chromium with other alloys. Valve or bearing steels, high-temperature alloys, or electrical grades with analyses meeting the definition for stainless steels are included. All tool-steel grades are excluded.

Heat-resisting steel includes all steel containing 4 percent or more but less than 10 percent of chromium (excluding tool-steel grades).

The production of high strength-low alloy steels has grown faster in the last 10 years than production of any other grade of steel. The average annual growth rate from 1959 through 1968 was 20 percent. Production in 1968 reached 4 million tons, a 23-percent increase over that of 1967; and shipments totaled 3 million tons, a 20-percent increase. Line pipe made up 38 percent of the product mix while the construction industry accounted for 57 percent of the market. The growth in demand is accounted for mainly by the increase in substitution of this alloy for carbon structural steel and by new applications in heavy machinery construction, vehicle manufacture, shipbuilding, deep-submergence vessels, off-shore oil well platforms, high-pressure tanks, and rocket motor construction.

The production of silicon sheet steels, used in the manufacture of electric motor stators and rotors, transformers, generators, and various communications equipment, dropped 12 percent to about 1 million tons in 1968.

Total production of all grades of alloy steel, excluding stainless but including 55,000 tons of alloy steel for castings, was 13,761,000 tons, an increase of 9 percent over that in 1967.

Total production of all grades of stainless steel, including 2,000 tons of stainless steel for castings, decreased 1 percent to 1,432,000 tons. Production of austenitic (AISI 200 and 300) stainless steel decreased 3 percent to 970,428 tons, while production of series 400 steels decreased 2 percent to 287,759 tons. Production of AISI type 500 and all other high-chromium heat-resisting steels increased 10 percent to 38,090 tons.

The production of alloy and stainless steel in the basic oxygen converters rose to 20 percent of the total. Open hearth furnaces accounted for 41 percent of this production and electric furnaces for 39 percent.

Materials Used in Steelmaking.—Ferrous scrap and pig iron consumed in steelmaking furnaces totaled 147.2 million tons and provided the bulk of the iron units for new steel. The small amount of iron contributed to the furnace melt by iron ore and ferroalloys was incidental to the primary function of these additives. The scrap portion of the furnace charge increased to 45.7 percent from 44.7 percent in 1967, reversing a 3-year downward trend in the use of scrap relative to pig iron. New electric furnace capacity in 1968 boosted scrap use sufficiently to outweigh the loss due to the obsolescence of some open-hearth furnaces. Other trends in the changing use pattern of raw materials for steelmaking were also noted. The consumption of iron ore and agglomerates deviated little from the downward trend line of the last 10 years. The consumption of fluorspar, lime, and oxygen continued to increase, paralleling the proliferation of basic oxygen steel shops, while the consumption of limestone continued downward, reflecting the steady decline of open hearth steelmaking. According to the AISI, 497,186 tons of fluorspar, 3,130,562 tons of limestone, 4,597,820 tons of lime, and 712,755 tons of other fluxes were consumed in steelmaking furnaces in 1968. Comparable data for 1967 were the following: Fluorspar, 488,162 tons; limestone, 3,403,944 tons; lime, 4,054,875 tons; and other fluxes, 768,264 tons. Total consumption of oxygen in steelmaking furnaces reached 151.2 billion cubic feet, an 8-percent increase over the 140.5 billion cubic feet consumed in 1967. Of the total, basic oxygen furnaces consumed 58 percent; open-hearth furnaces, 36 percent; and electric furnaces, 6 percent. An additional 34.9 billion cubic feet of oxygen, which was used for such purposes as iron smelting, scrap preparation, slab conditioning, welding, and maintenance, brought the oxygen consumption of the iron and steel industry in 1968 to a grand total of 186.1 billion cubic feet.

CONSUMPTION OF PIG IRON

Consumption of pig iron, excluding molten pig iron used for ingot molds and direct castings, decreased slightly from that for 1967. Of the three States using 54 percent of the pig iron, consumption in Pennsylvania and Indiana decreased, while consumption in Ohio increased. Consumption of pig iron in basic oxygen furnaces, which amounted to only 5 million tons in 1962, was 39 million tons in 1968, or 47 percent of the total consumption by all types of furnaces. It is expected that in 1969, basic oxygen furnace shops will be the major consumer of pig iron.

PRICES

Three major producers of tool and high-speed steels increased prices for some grades in January. From February through June most of the large steel producers had an extended payment plan in effect in which the customer was generally allowed an additional 120 days beyond the regular payment date on all steel purchased as a protection against a possible strike. Prior to the labor contract expiration, price changes were flexible—both up and down—with price concessions reported for specific geographic areas where import competition was the greatest. After the labor contract settlement, effective August 1, the major steel producers announced selective price increases which equaled about 2.5 percent on an average for all shipments. A surprising $25 reduction for hot-rolled sheet in November lowered the price of this major product to $88.50 per net ton; however, it was announced later that part of the price reduction would be rescinded, effective January 1, 1969.

The composite base price of pig iron, as reported by Iron Age, remained at the 1967 value, $56.38 per short ton, throughout the year. The finished steel base price rose from 6.496 cents per pound at the beginning of the year to 6.767 cents per pound in August but dropped to 6.538 cents per pound at yearend. The average for the year was 6.599 cents per pound.

FOREIGN TRADE

Historically, the position of the United States in world steel trade suffers periodic setbacks when new labor contracts must be negotiated and historically, the position lost is never fully regained. The setback in 1968 was particularly severe, as the U.S. net trade deficit for major iron and steel products amounted to 15.4 million tons valued at $1.4 billion.

Exports of steel products increased 29 percent in 1968 but remained small relative to imports. Exports of all product groups with the exception of plates showed sizable gains in volume over that for 1967. Exports of semifinished material advanced the most and represented about one-fourth of the export product mix. Asia was the principal regional outlet for exports as U.S. Agency for International Development shipments continued to be an important factor. Exports to Latin America enjoyed the highest gain in 1968, increasing 53 percent over those in 1967.

Imports of steel products increased by over 6.5 million tons (57 percent) to 18 million tons in 1968, again setting a new record and preserving the upward trend for the seventh consecutive year. Imports of sheets and strip products showed sizable advances and accounted for 41 percent of the total product mix. In contrast, to 1967, Japan supplanted the European Coal and Steel Community (ECSC) countries as the leading foreign source of supply in the U.S. market. Japanese exports to this market increased by 2.8 million tons (63 percent), in 1968, rising to a record of 7.3 million tons and accounting for 41 percent of total U.S. imports. ECSC steel exports to the United States increased by 2.3 million tons (47 percent) to reach 7.1 million tons or 40 percent of total U.S. imports in 1968.

WORLD REVIEW

For the 10th consecutive year, the world's raw steel output expanded to a new record in 1968, 582 million tons. This represented an increase of about 39 million tons or 7 percent over that for 1967. Raw steel production increased in every major producing country. Growth in steel capacity showed no signs of letting up, due primarily to a 28-percent increase in basic oxygen converter capacity. By the end of 1969, it was estimated there will be 265 million tons of world capacity for this process. Worldwide annual surplus is estimated at 50 to 60 million tons, and expansion programs currently underway indicate that within the next few years, this excess figure may well double unless world steel consumption rises rapidly.

European Coal and Steel Community (ECSC).—The ECSC countries enjoyed a good production year, increasing total steel output in 1968 by 9.6 million tons, or 10 percent, to 108.7 million tons. All the member countries contributed to this increase, but principally West Germany, Belgium-Luxembourg, and Italy. ECSC exports rose by 5.3 million tons in 1968, mostly attributable to exchanges among the member nations, which accounted for three-quarters of the total gain, while shipments to third countries accounted for only a quarter.

Argentina.—Kaiser Engineers, Oakland, Calif., was awarded a contract by Armco International, the prime contractor to Sociedad Mixta Siderúrgica Argentina (SOMISA), for engineering, design, procurement assistance, construction management, and other services relating to the 1-million-ton expansion program for the General Savio Steel Plant, Argentina's largest integrated steelworks. The $200 million program, which was authorized by the Government in 1967, consists of three phases, the first of which was activated in May through a $33.7 million credit authorized by the U.S. Export-Import Bank. The third phase is scheduled for completion in 1973.

Australia.—The first phase of the expansion program at the Kwinana, Western Australia, plant of Australian Iron and Steel Pty. Ltd., subsidiary of The Broken Hill Proprietary Co., Ltd. (BHP), was completed at a cost of of $67 million. Total direct investment by the BHP in Western Australia has now reached $100 million and projected future expansion in the next decade, including steelmaking facilities, will increase BHP's total investment at Kwinana and Koolyanobbing to about $258 million.

With the commissioning of the blast furnace and associated facilities at Kwinana (located about 22 miles south of Perth), and other facilities in the future, BHP will have established Australia's fourth integrated iron and steel works, on the shores of Cockburn Sound, near the southwestern corner of Australia. The iron ore deposits are located at Koolyanobbing, 308 miles east of Perth.

Belgium.—Steel production in 1968 was characterized by an extraordinary jump (19.5 percent versus 12.5 percent in 1967) and by a rapid increase in the share of output produced by the oxygen process. The major cause for both phenomena was the Siderurgie Maritime S.A. (SIDMAR) plant in Ghent which began operating in May 1967, and which puts its second blast furnace into operation in May 1968. Neglecting SIDMAR's production, the 1968 increase was approximately 10 percent, or slightly more than the ECSC average of 9.7 percent. The production of oxygen steel was begun in Belgium in 1963. In 1968 it accounted for 39 percent of production. Production by the Thomas (Bessemer) method has conversely fallen from a peak of 7.2 million tons in 1964 (83 percent of production) to 6.5 million tons in 1968 (57 percent of production).

Situated on the Terneuzen Canal with access to oceangoing vessels, SIDMAR is seen as part of European steel's "March to the sea." It is supplied with ore from Sweden and Brazil which is suitable for oxygen steel. It is believed that SIDMAR, or similarly located plants, will account for most of Belgium's new steel capacity in the future.

Of the total 1968 production, Belgium consumed 22.5 percent, exported 49.3 percent to her European Community partners, and exported 28 percent to third countries. The comparable data for 1960—26.7 percent, 30.2 percent, and 43.1 percent, respectively—show that Belgium's export market has shifted from third countries to her European partners. This trend has been encouraged not only by the operation of the Common Market but also by stiff Japanese competition in third country markets. Belgium's Asian market, for example, has almost disappeared. The notable exception to this trend has been in sales to the U.S. which reached an estimated record level of 1.14 million tons in 1968 (an increase of almost 17 percent over that in 1967). For the first year since 1959, West Germany was Belgium's biggest steel customer; 1968 sales to West Germany were 80 percent higher than in 1967. On the other hand, sales to France which have been increasing rapidly in recent years, slowed down to a growth of only 4 percent. The principal cause for this slowdown was the imposition of temporary import restrictions in France in the summer of 1968. As a group, Belgium's European Community partners bought 30 percent more Belgian steel in 1968 than in 1967.

Brazil.—The situation for the steel industry improved considerably in 1968 as demand for steel products rebounded after stagnating in 1967. Record activity in both civil construction and the automotive industry were the major contributors to a resumption of a good growth rate for steel consumption. Apparent consumption was erratic in the years 1964 through 1967 as a result of complex economic and political factors. In the 20 years prior to 1964, Brazil had enjoyed an almost uninterrupted growth in domestic steel consumption (about 6 percent per year) and in steel production (about 9 percent per year). Production in 1968 increased 20 percent as the industry was operating near full capacity. A 20-percent price increase in steel products in January helped the industry to recoup profit losses incurred in the period 1964 through 1967.

In April 1967 President Costa e Silva signed Decree No. 60.642 establishing a Consultative Group for the purpose of drafting a comprehensive National Steel Plan. The group completed its task by the close of 1967, and the plan with minor modifications was approved by the President in March 1968. In general terms the plan calls for an overall increase of 76 percent in steel productive capacity by 1972; greater specializations of production in the large steel plants; a feasibility study for a new integrated steel plant at Ponta do Tubarão outside of Vitória, primarily geared to the export market; the construction of two regional plants; and several measures to improve the financial situation of the industry. The expansion plan foresees total new investment in the steel sector of $655 million in the 5-year period, 1968–72, and forecasts that demand will rise from 4.6 million tons in 1968 to 6.8 million tons in 1972.

Canada.—The Government of Nova Scotia gave cabinet approval in December for the purchase of the Sydney steel plant from Dominion Steel and Coal Corp. (Dosco) of Montreal. Total cost was estimated to be about $10.5 million. Also approved was a 5-year, $50 million program to modernize the 70-year-old steel mill. In 1967, Dosco announced intentions of closing the plant because of heavy operating losses. After a Crown Corporation, Sydney Steel Corp. (Sysco), took over operation in January 1968, the plant began to show a profit. As a result of more efficient production methods and sales of steel rails to South Korea, Chile, and the United States, Sysco ended the year with a profit of about $2.5 million for the plant.

The Steel Co. of Canada Ltd. (Stelco), announced a $50 million program to replace eight open-hearth furnaces at its Hilton plant in Hamilton, Ontario, with two basic oxygen furnaces. Installation of the furnaces in 1971 will increase the company's production capacity from 4.75 million tons to 6 million tons per year.

Germany, West.—The output of pig iron, raw steel, and finished rolled steel in 1968 for West Germany were the highest on record. The accelerated economic recovery in the Federal Republic during 1968 boosted demand for finished steel to over 31 million tons, a 24-percent increase over that for 1967. The higher demand reflected an approximate 10-percent increase in steel consumption; additional large quantities of steel were purchased by consumers and dealers for building up inventories which had been excessively depleted during 1966 and 1967. West Germany's large export surplus in steel trade declined noticeably in 1968 as imports surged almost 50 percent, while exports increased by about 10 percent, much less than domestic sales. This development mirrored the strongly increased attractiveness of the German market for both domestic and foreign steel suppliers.

Iran.—Ground breaking ceremonies were held in March for Iran's first integrated steel plant which will be built under a U.S.S.R.-Iranian agreement signed in December 1965. During the initial phase of operation, the plant will produce about 600,000 tons of raw steel and 350,000 tons of rolled products in the form of sections, shapes, and reinforcing bars. During the second phase of operation, productive capacity will be doubled to provide for the production of flat-rolled products; production is expected to begin in 1971. The steel mill complex will consist of coke and chemical production facilities, an iron ore agglomeration section, a blast furnace shop, two basic oxygen converters, continuous casting units, a rolling mill, a refractory materials plant, and various auxiliary units.

Japan.—The upsurge in business, which began late in 1965, continued in 1968 and was expected to continue throughout 1969 despite a financial retrenchment policy adopted in September to improve the Japanese balance of payments position. The high growth rate of raw steel production experienced in 1966 (16 percent) and in 1967 (30 percent) slowed to 7 percent in 1968 but was still higher than the average growth rate of world production. Japanese steel companies produced 73.7 million tons of steel in 1968, second only to the U.S.S.R. and the United States. Domestic demand and prices stagnated during the first half of the year under pressure from inventory adjustments and other steps taken by the user industries to meet the business curtailment policy. Domestic demand turned upward during the second half of the year due principally to booming requirements of the construction industry, the best market for steel in Japan. Steel prices rose an average of $3 per ton at yearend.

Spain.—Total demand for finished steel continued to outstrip supply. In spite of the 18-percent increase in finished steel production in 1968, Spain was still far from self-sufficient. Steel consumption, up to 7.3 million tons from 6.8 in 1967, led the economy's upswing during 1968, exceeding even the most optimistic projections. The Spanish Government projected a quick return to higher consumption patterns during the next 3 years and industry sources predicted that total demand for finished steel would hit 8.5 million tons in 1969. Studies completed by the steel industry association indicated that the present rate of industry expansion will bring domestic production in line with demand in about 1972, when steel output will have reached 10 million tons. To achieve this goal, the industry has been modernizing at a fast rate. Presently, one-half of Spanish steel output is produced with equipment less than 3 years old, and another 25 percent with equipment less than 6 years old.

TECHNOLOGY

The uninterrupted upward trend in blast furnace productivity since the end of World War II continued in 1968 as higher pig iron production was achieved with fewer furnaces and at lower cost. In 1945, 216 blast furnaces produced 53 million tons of pig iron; in 1968, 150 blast furnaces produced 89 million tons of pig iron. Expressed more exactly, the average production of pig iron per blast furnace day has risen steadily from 785.2 tons in 1945 to 1,624.5 tons in 1968. At the same time the coke consumption rate, the largest single conversion cost item in the manufacture of iron, has fallen from about 1,900 pounds of coke per ton of pig iron produced in 1945 to 1,250 pounds per ton produced in 1968. These improvements have been due to many factors, including larger and better designed blast furnaces, better operating techniques, improved burden preparation, higher blast temperatures, and more recently, fuel injection, oxygen enrichment, and higher top pressure.

The trend toward larger blast furnaces continued upward in 1968 with the Japanese and Russian steelmakers leading the rest of the world. In February, the Fukuyama Works of Nippon Kopan K.K. blew in its #2 furnace having a hearth diameter of 37 feet and a working volume of 80,500 cubic feet. A world record of 6,600 tons of iron per day was claimed for the furnace on October 22. At yearend all of Japan's six largest steel companies were engaged in ambitious expansion programs involving some of the largest blast furnaces ever built. At least two of the furnaces under construction have a design capacity of over 7000 tons of iron per day. In the

U.S.S.R., three furnaces of over 95,000 cubic feet volume were blown in during the year and a furnace with a volume of about 113,000 cubic feet was reported to be in the design stage.

The outstanding technological development of 1968 was the industrialization of several direct reduction ironmaking and steelmaking techniques which bypass the blast furnace. The intriguing aspect of these methods is that they not only obviate the high initial investment of a blast furnace and associated facilities, but that they have potential application to a continuous steelmaking system.

At yearend a new ironmaking process went on stream at the McWane Cast Iron Pipe Company of Mobile, Ala., which uses a new type of pelletizing system in conjunction with electric melting furnaces to produce high-grade pig iron or hot base metal designed especially for ductile iron or gray iron production.

Following World War II McWane Cast Iron Pipe Company faced a shortage of high-quality pig iron; therefore, a long-range research program was assigned to Battelle Memorial Institute to develop an integrated process which would be nonstop from iron ore to final casting. A basic process was developed known as the Dwight Lloyd McWane (D-LM) reduction process. Following completion of the research work, McDowell-Wellman Engineering Company of Cleveland, Ohio, constructed and operated a pilot plant at Cleveland to evaluate materials from around the world including the following types of iron ore: Hard magnetites; titaniferous magnetites; specular hematities; earthy hematites; goethites; and dust, sludge, and fume from metallurgical plants. A feasibility study showed that good water transportation would be a decisive economic factor in industrializing the process and so in August 1966 McDowell-Wellman began construction of a commercial plant on the western shore of Mobile Bay at Mobile, Ala.

The D–LM process consists of the following five steps: 1. Proportioning raw materials; 2. Grinding and filtering; 3. Balling green pellets; 4. Carbonizing green pellets; 5. Smelting the self-fluxing and self-reducing pellets in an electric furnace.

The chemical and physical changes that take place during the carbonizing step may be compared with those that occur in a blast furnace process. First, the coal becomes carbonized paralleling the coke-oven function; second, the charge becomes agglomerated paralleling the sinter or pellet plant function; and third, the ore becomes preheated and prereduced paralleling the function of shaft reactions in a blast furnace. In the D–LM carbonizing step, these simultaneous reactions take place rapidly within a 15- to 20-minute period. This is said to be the key factor for the economic feasibility of the process.

The plant at Mobile will operate at a capacity of about 200,000 tons per year, 20 percent of the capacity of a modern blast furnace. Capital cost requirements for the D–LM plant are in the order of $50 per annual ton. Capital cost requirements for a blast furnace, agglomeration plant, and coking ovens to operate at a capacity of 200,000 tons per year are estimated to be in the range from $150 to $200 per annual ton. Estimates of capital costs for plants of 1 million tons per year capacity are $40 per annual ton for a D–LM plant and $100 per annual ton for a blast furnace plant with coke and pellet facilities.

Potential of the D–LM process is evidenced by its compatibility to continuous steelmaking; by its product range from pig iron (including shot) to ferroalloys; by its raw material range from iron ore fines to waste materials such as those in tailings piles, slag dumps, and red mud lagoons; and by the fact that no liquid effluent leaves the plant and no air pollution problems are created.[3]

A new plant under construction at Portland, Ore., by Midland-Ross Corp. will produce highly metalized iron ore pellets using a gaseous reduction process developed by the Surface Combustion Division of the corporation. Reducing ore with gas is suited to the Pacific Northwest because of the availability of cheap natural gas and the scarcity of high-quality coal. The plant will receive high-grade fines in slurry form from the Marcona Corp. in Peru and convert them to 95-percent-iron pellets. These will serve as a continuous feed for an adjacent electric-furnace shop nearing completion by Oregon Steel Mills. The direct reduction plant has been deliberately modulized at a single capacity so that complete duplication can be accomplished for further expansions.[4]

---

[3] Ban, Thomas E., and Donald C. Violetta. D–LM—New Commercial Ironmaking Process. Iron and Steel Eng., v. 45, No. 9, September 1968, pp. 101–114.

Jeffery, Warren C., and T. E. Ban. Nonstop From Iron Ore to Casting. Pres. at American Foundrymen's Society meeting, Pittsburgh, Pa., May 11, 1967.

The Stelco-Lurgi/Republic Steel-National Lead (SL/RN) prereducing process, a rotary kiln-solid fuel reduction process, was used to evaluate iron ore from Hammersly Iron Pty., Ltd., of Western Australia. The Steel Company of Canada, Ltd. (Stelco), produced the pellets which were then continuously fed to an electric furnace at Stelco's Edmonton, Alberta, plant. The tests results were sound, showing excellent removal of sulfur and phosphorus. Hammersly will build a 1-million-ton direct reduction plant using the SL/RN process in Dampier, Australia, by 1970 or 1971.

Additional plants using the SL/RN process are being constructed at Inchon Heavy Industry Corp. (South Korea) and at the New Zealand Steel Co. In New Zealand, high-iron beach sands will be used to produce sponge iron. In Brazil, construction was underway on a new steel plant, Aços Finos Piratini, S.A., adjacent to a coal mine and thermoelectric plant at Charquedas, Rio Grande do Sul. The plant will use the SL/RN process to produce 72,000 tons of sponge iron annually. The steel plant will have three electric-arc furnaces with a capacity of 50,000 tons annually.

Falconbridge Nickel Mines Ltd. (Canada) developed a new nickel-bearing reduced iron ore pellet containing 90 percent iron and 1.5 percent nickel. The pellets will be sold primarily to alloy steel and stainless steel producers and are capable of being charged directly into steel-making furnaces. A new $35 million concentrator is under construction in the Sudbury area to produce 500,000 tons of pellets annually using pyrrhotite as the raw material. The plant is expected to go onstream late in 1969.

With the commercialization of continuous direct reduction processes, and the technical success of continuous electric furnace melting, the long sought goal of continuous steelmaking appears within reach. Continuous steelmaking through another approach, the oxidation route, appears more distant but has experienced significant progress in the last several years. The chemical reactions within a blast furnace are continuous, only the tapping of hot metal is discontinuous. The use of two and more tap holes in modern, large blast furnaces to adequately handle high production rates is a step toward a more continuous flow of hot metal. The reaction of hot metal with oxygen in steelmaking, however, remains essentially a batch process. Two European steelmaking processes, which are based on a large increase in the reaction surface of the hot metal, show promise of supplying the missing link in the oxidation route. Spray steelmaking, developed by the British Iron & Steel Research Association (BISRA), is based on the atomization of a falling stream of hot metal by oxygen jets. Two steel companies in England have installed spray steelmaking units which process hot metal at the rate of from 60 to 80 tons per hour. Many economic advantages are claimed for this process, however, problems of large scale operation such as temperature control, flux feeding, fume removal, and slag foaming must still be solved.

A process under development in France by IRSID with the financial help of the European Coal and Steel Community, is based on a large increase of the area of hot metal inside a mass of slag. A continuous slag-metal-gas complex is set up in a refining vessel which overflows into a decanting vessel where separation of the slag and metal phases takes place. The raw steel flows in a continuous stream into a third vessel where deoxidation, alloying, or other refining steps may be carried out. At year-end a 700-ton per day pilot plant was under construction in eastern France to evaluate the economics of the process.[5]

---

[4] Sturgeon, James H. Oregon Steel Mills To Utilize Prereduced Pellets. Iron and Steel Eng., v. 45, No. 6, June 1968, pp. 197, 201.

[5] Spray Steelmaking Spreads Its Wings. Steel. V. 162, No. 8, February 19, 1968, pp. 41–43.
Trentini, Bernard. Comments on Oxygen Steelmaking. Trans. Met. Soc. AIME, v. 242, No. 12, December 1968, pp. 2377–2388.

Table 2.—Pig iron produced and shipped in the United States, in 1968, by States

(Thousand short tons and thousand dollars)

State	Production	Shipped from furnaces	
		Quantity	Value
Alabama	4,378	4,455	$244,515
Illinois	6,205	6,262	350,950
Indiana	12,475	12,502	713,723
Ohio	15,758	15,694	928,217
Pennsylvania	21,008	21,078	1,180,546
California, Colorado, Utah	4,873	4,887	287,917
Kentucky, Maryland, Texas, West Virginia	10,841	10,909	623,111
Michigan, Minnesota	7,324	7,340	404,417
New York	5,902	5,958	334,421
Total [1]	88,767	89,085	5,067,817

[1] Data may not add to totals shown because of independent rounding.

Table 3.—Foreign iron ore and manganiferous iron ore consumed in manufacturing pig iron in the United States, by source of ore

(Thousand short tons)

Source	1967 [1]	1968 [2]
Brazil	1,978	1,516
Canada	3,933	2,498
Chile	1,641	1,534
Peru	236	125
Venezuela	5,298	6,124
Other countries	1,509	1,833
Total	14,595	13,630

[1] Excludes 24,340 tons used in making agglomerates.

[2] Excludes 19,550 tons used in making agglomerates.

Table 4.—Pig iron shipped from blast furnaces in the United States, by grades [1]

(Thousand short tons and thousand dollars)

Grade	1967			1968		
	Quantity	Value		Quantity	Value	
		Total	Average per ton		Total	Average per ton
Foundry	1,534	$87,072	$56.76	1,611	$90,578	$56.22
Basic	79,931	4,565,113	57.11	83,560	4,756,441	56.92
Bessemer	2,844	169,338	59.54	1,496	84,889	56.74
Low-phosphorus	215	13,055	60.72	177	10,364	58.55
Malleable	1,996	113,851	57.04	1,880	105,156	55.93
All other (not ferroalloys)	299	17,272	57.77	361	20,389	56.48
Total [2]	86,819	4,965,700	57.20	89,085	5,067,817	56.89

[1] Includes pig iron transferred directly to steel furnaces at same site.

[2] Data may not add to totals because of individual rounding.

Table 5.—Number of blast furnaces (including ferroalloy blast furnaces) in the United States, by States

State	January 1, 1968			January 1, 1969		
	In blast	Out of blast	Total	In blast	Out of blast	Total
Alabama	[r] 9	[r] 8	[r] 17	9	9	18
California	4	--------	4	4	--------	4
Colorado	4	--------	4	4	--------	4
Illinois	14	4	18	13	5	18
Indiana	22	2	24	20	4	24
Kentucky	2	1	3	2	1	3
Maryland	10	--------	10	7	3	10
Michigan	9	--------	9	8	1	9
Minnesota	1	1	2	1	1	2
New York	12	3	15	12	3	15
Ohio	33	14	47	27	20	47
Pennsylvania	[r] 39	19	[r] 58	35	23	58
Tennessee	-------	3	3	--------	3	3
Texas	2	--------	2	2	--------	2
Utah	3	--------	3	2	1	3
West Virginia	4	--------	4	4	--------	4
Total	[r] 168	[r] 55	[r] 223	150	74	224
Ferroalloy blast furnaces	[r] 5	[r] 2	[r] 7	4	2	6
Grand Total	173	57	230	154	76	230

[r] Revised.

Source: American Iron and Steel Institute.

Table 6.—Iron ore and other metallic materials, coke and fluxes consumed and pig iron produced in the United States, by States

(Thousand short tons)

Year and State	Metalliferous materials consumed							Net coke	Fluxes	Pig iron produced	Metalliferous materials consumed per ton of pig iron made				Coke and fluxes consumed per ton of pig iron	
	Iron and manganiferous ores		Agglomerates	Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Net total				Net ores and agglomerates [1]	Net scrap [2]	Miscellaneous [3]	Total	Net coke	Fluxes
	Domestic	Foreign														
1967																
Alabama	2,252	1,178	4,279	7,608	118	13	7,739	3,546	786	4,307	1.766	0.027	0.008	1.797	0.823	0.183
Illinois	3,961	W	6,399	10,129	368	338	10,835	4,273	1,378	6,222	1,628	.058	.054	1.741	.687	.221
Indiana	4,836	850	14,230	19,320	191	465	19,976	7,278	1,659	12,167	1.588	.016	.038	1.642	.598	.136
Ohio	4,321	1,095	16,123	20,940	1,024	1,508	23,472	9,509	3,041	14,377	1.457	.071	.105	1.633	.661	.212
Pennsylvania	5,535	4,643	21,528	30,882	959	1,594	33,435	13,042	2,530	20,541	1.503	.047	.078	1.628	.635	.123
California, Colorado, Utah	W	W	4,823	8,218	870	145	9,233	2,811	860	4,762	1.726	.183	.030	1.939	.590	.181
Maryland, West Virginia, Kentucky, Texas	W	3,319	12,458	17,933	122	905	18,960	6,648	1,689	10,826	1.656	.011	.084	1.751	.614	.156
Michigan and Minnesota	W	W	10,528	12,818	232	187	13,237	4,448	1,230	7,450	1.721	.031	.025	1.777	.597	.165
New York	1,363	544	7,667	9,382	215	487	10,084	3,731	1,079	6,148	1.526	.035	.079	1.640	.607	.176
Total [4]	28,175	14,595	98,035	137,230	4,099	5,643	146,972	55,280	[5] 14,252	86,799	1.581	.047	.065	1.693	.637	.164
1968																
Alabama	1,863	W	4,445	7,531	142	24	7,697	3,342	668	4,378	1.720	.032	.005	1.758	.763	.153
Illinois	W	W	7,380	10,740	250	316	11,306	3,964	1,126	6,205	1.731	.040	.051	1.822	.639	.181
Indiana	W	W	15,629	19,746	258	522	20,526	7,236	1,178	12,475	1.583	.021	.042	1.645	.580	.094
Ohio	4,401	1,440	17,927	23,242	987	1,460	25,689	10,400	3,219	15,758	1.475	.063	.093	1.630	.660	.204
Pennsylvania	6,397	4,983	22,744	33,462	904	1,539	35,905	13,010	3,041	21,008	1.593	.043	.073	1.709	.619	.145
California, Colorado, Utah	3,430	W	4,835	8,160	178	149	8,487	2,872	861	4,873	1.675	.037	.031	1.742	.589	.177
Maryland, West Virginia, Kentucky, Texas	W	W	13,830	16,674	251	928	17,853	6,687	1,354	10,841	1.538	.023	.086	1.647	.617	.125
Michigan and Minnesota	1,231	W	10,394	11,281	223	207	11,711	4,421	1,317	7,824	1.540	.030	.028	1.599	.604	.180
New York	1,269	W	W	9,131	188	400	9,719	3,531	808	5,902	1.547	.032	.068	1.647	.598	.137
Total [4]	26,977	11,116	104,988	139,967	3,382	5,545	148,893	55,463	[6] 13,572	88,767	1.577	.038	.062	1.677	.625	.153

W Withheld to avoid disclosing individual company confidential data; included with total.

[1] Net ores and agglomerates equal ores plus agglomerates plus flue dust used minus flue dust recovered.

[2] Excludes home scrap produced at blast furnaces.

[3] Does not include recycled material.

[4] Data may not add to totals shown because of independent rounding.

[5] Fluxes consisted of the following: 8,246 limestone, 5,604 dolomite, and 402 other fluxes excluding 5,111 limestone, 2,877 dolomite, and 317 other fluxes used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

[6] Fluxes consisted of the following: 7,429 limestone, 5,824 dolomite, and 319 other fluxes excluding 5,151, limestone, 3,258 dolomite, and 181 other fluxes used in agglomerate production at or near steel plants and an unknown quantity used in making agglomerates at mines.

Table 7.—Steel production in the United States, by type of furnace[1]

(Thousand short tons)

Year	Open hearth		Bessemer	Basic oxygen process	Electric	Total
	Basic	Acid				
1964	97,655	443	858	15,442	12,678	127,076
1965	93,866	327	586	22,879	13,804	131,462
1966	84,804	221	278	33,928	14,870	134,101
1967	70,550	140	(3)	41,434	15,089	127,213
1968	65,836	(2)	(3)	48,812	16,814	131,462

[1] Includes only that steel for castings produced in foundries operated by companies manufacturing steel ingots. Omits about 2 percent of total steel production.
[2] Basic and acid open hearth production data reported separately in previous years.
[3] Included with open hearth.

Source: American Iron and Steel Institute.

Table 8.—Metalliferous materials consumed in steel furnaces in the United States

(Thousand short tons)

Year	Iron ore		Agglomerates[1]	Pig iron	Ferro-alloys[2]	Iron and steel scrap
	Domestic	Foreign				
1964	2,114	4,816	1,379	78,925	1,819	64,348
1965	1,818	4,400	[3] 1,061	81,040	1,898	68,272
1966	1,348	3,768	[4] 870	83,947	1,915	68,778
1967	954	2,905	[5] 600	80,404	1,818	65,027
1968	958	2,514	[6] 684	79,938	1,404	67,281

[1] Includes consumption of pig iron and scrap by ingot producers and iron and steel foundries.
[2] Includes ferromanganese, spiegeleisen, silicomanganese, manganese briquets, manganese metal, ferrosilicon, ferrochromium alloys, and ferromolybdenum.
[3] Includes 567 sinter, 386 pellets, 100 nodules, and 8 other agglomerates (418 foreign origin.)
[4] Includes 435 sinter, 348 pellets, 86 nodules, and other agglomerates (348 foreign origin.)
[5] Includes 306 sinter, 217 pellets, 77 modules and other agglomerates (378 foreign origin.)
[6] Includes 290 sinter, 299 pellets, 95 nodules and other agglomerates (337 foreign origin.)

Table 9.—Consumption of pig iron[1] in the United States, by type of furnace

Type of furnace or equipment	1968	
	Thousand short tons	Percent of total
Open hearth	40,145	48.3
Oxygen converter	39,284	47.3
Electric	519	.6
Cupola	2,909	3.5
Other furnaces[2]	273	.3
Total	83,131	100.0

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes air, induction, and vacuum melting furnaces, and Bessemer converters.

Table 10.—Average value of pig iron at blast furnaces in the United States, by States

(Per short ton)

State	1968
Alabama	$54.89
California, Colorado, Utah	54.91
Illinois	56.04
Indiana	57.09
New York	56.13
Ohio	59.14
Pennsylvania	56.01
Other States[1]	56.31
Average	56.89

[1] Includes Kentucky, Maryland, Michigan, Minnesota, Texas and West Virginia.

Table 11.—Consumption of pig iron[1] in the United States, by States

(Thousand short tons)

State	1968
Alabama	3,769
Arizona	W
California	2,188
Colorado	980
Connecticut	22
Delaware	W
Florida	W
Georgia	11
Illinois	4,772
Indiana	12,393
Iowa	54
Kansas	2
Kentucky	1,592
Maryland	5,641
Massachusetts	31
Michigan	7,206
Minnesota	461
Missouri	24
Montana	W
New Jersey	81
New York	5,492
North Carloina	37
Ohio	14,566
Oklahoma	14
Pennsylvania	18,037
Rhode Island	19
South Carolina	W
Tennessee	127
Texas	1,197
Utah	W
Vermont	6
Virginia	W
Washington	8
West Virginia	W
Wisconsin	165
Other States	4,236
Total	83,131

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Excludes molten pig iron used for ingot molds and direct castings.

Table 12.—Free-on-board value of steel mill products in the United States in 1967[1]

(Cents per pound)

Product	Carbon[2]	Alloy[2]	Stainless[2]	Average
Ingots	6.642	19.306	43.797	16.307
Semifinished shapes and forms	5.943	12.043	52.977	7.336
Plates	6.916	9.793	56.729	8.039
Sheets and strips	7.389	16.040	44.289	8.363
Tin mill products	9.447	--------	--------	9.447
Structural shapes and piling	6.677	(3)	--------	6.677
Bars	7.804	15.077	67.121	9.746
Rails and railway-track material	7.961	--------	--------	7.961
Pipes and tubes	9.662	14.808	117.116	11.589
Wire and wire products	13.159	36.063	85.023	14.565
Other rolled and drawn products	12.104	19.916	77.406	12.940
Average total steel	7.903	13.826	56.507	9.023

[1] This table represents the weighted average value based on the quantity of each type of steel shipped; therefore, it reflects shifts in the distribution of the 3 classes of steel.

[2] Transfers to other plants of the same company are included with shipments to other companies.

[3] Included with plates.

Table 13.—U.S. exports of major iron and steel products

Products	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
SEMIMANUFACTURED				
Ingots and other primary forms:				
Puddled bars and pilings, blocks, lump and other primary forms of iron or steel, n.e.c.	5,880	$699	4,462	$729
Blooms, billets, ingots, slabs, sheet bars and roughly forged pieces	302,498	26,330	551,708	48,201
Coils for rerolling	60,486	34,446	50,432	26,987
Blanks for tubes and pipes, iron or steel	1,453	251	2,095	241
Total	370,317	61,726	608,697	76,158
Bars, rods, angles, shapes and sections:				
Wire rods	7,107	1,598	12,317	2,316
Bars, rods, and hollow-drill steel	78,857	26,193	100,200	28,251
Concrete reinforcing bars	21,577	2,904	26,097	3,903
Angles, shapes and sections	113,789	18,454	121,899	20,757
Plates and sheets:				
Steel plates	15,622	8,517	15,584	7,878
Steel sheets	[r] 138,591	[r] 41,895	273,043	49,486
Black plate	19,854	1,895	27,867	3,097
Iron and steel plates, n.e.c	254,410	53,725	209,269	43,628
Tinplate and terneplate	283,542	[r] 42,246	293,265	44,550
Tinplate circles, cobbles, strip and scroll	15,380	1,485	15,267	1,405
Hoop and strip	56,874	28,071	56,022	26,456
Total	[r] 1,005,603	[r] 226,983	1,150,830	231,727
MANUFACTURES				
Rails, and railway track material	32,348	6,335	89,526	16,660
Wire	49,099	25,971	63,710	28,960
Cast-iron pressure pipe, soil pipe and fittings	[r] 64,572	[r] 13,316	49,098	13,320
Steel tube and pipe fittings, union and flanges	30,513	41,519	29,922	41,138
Malleable iron tube and pipe fittings, n.e.c	1,623	1,625	1,440	1,771
Electrical conduit fittings of iron or steel	10,655	8,040	12,123	6,806
Iron tube and pipe fittings, n.e.c	6,217	8,769	6,650	8,562
Seamless tube and pipe	183,802	77,165	228,877	83,999
Welded, clinched or riveted tubes and pipe	70,602	30,982	93,738	29,121
Castings and forgings	[r] 72,346	[r] 52,885	125,131	63,438
Total	[r] 521,777	[r] 266,607	700,215	293,775
Grand total	[r] 1,897,697	[r] 555,316	2,459,742	601,660

[r] Revised.

Table 14.—U.S. imports for consumption of pig iron, by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	13,241	$391	--------	--------	--------	--------
Belgium-Luxembourg	1,793	366	--------	--------	--------	--------
Brazil	--------	--------	--------	--------	33,240	$976
Canada	393,593	19,793	408,066	$20,821	416,383	18,048
Czechoslovakia	67,968	2,218	--------	--------	--------	--------
Finland	64,655	2,294	33,617	1,244	77,762	2,658
Germany:						
East	104,891	3,237	49,700	1,344	--------	--------
West	79,750	3,023	41,947	1,646	79,710	2,872
Mexico	--------	--------	28	1	--------	--------
Mozambique	22,801	572	--------	--------	--------	--------
Netherlands	4,506	177	9,869	381	29,495	1,143
Norway	--------	--------	10,900	399	61,616	2,037
Rhodesia, Southern	72,664	2,319	22,400	587	--------	--------
Rumania	32,599	956	--------	--------	--------	--------
South Africa, Republic of	133,824	4,723	--------	--------	--------	--------
Spain	9,002	272	--------	--------	21,221	741
Sweden	--------	--------	1,922	137	40,048	1,218
U.S.S.R.	185,394	5,567	--------	--------	--------	--------
United Kingdom	58	6	7,075	335	26,424	798
Venezuela	--------	--------	19,710	704	--------	--------
Total	1,186,739	45,914	605,234	27,599	785,899	30,486

Table 15.—U.S. imports for consumption of major iron and steel products

Products	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Iron products:				
Cast iron pipes, tubes and fittings	[r] 27,308	[r] $6,357	39,064	$9,433
Bars of wrought iron	306	93	478	173
Total	[r] 27,614	[r] 6,450	39,542	9,606
Iron and steel products:				
Ingots, blooms, billets, slabs and sheet bars	[r] 220,289	31,298	298,678	42,359
Bars of steel:				
Concrete reinforcing bars	567,026	42,003	739,756	53,514
Other bars	651,286	[r] 75,718	975,390	108,125
Plates and sheets:				
Black plate	9,887	1,001	6,669	648
Steel plates	[r] 1,030,199	[r] 96,872	1,779,449	159,840
Steel sheets	[r] 3,692,483	[r] 363,478	6,359,405	627,234
Plates, sheets and strip of iron or steel	[r] 527,429	[r] 76,375	985,484	138,050
Strip of iron or steel	67,591	23,112	90,961	28,873
Hollow drill steel	5,014	1,953	3,708	1,351
Wire rods of steel	1,076,472	[r] 101,866	1,600,373	150,488
Sheet piling	29,669	3,050	67,545	6,654
Pipes, tubes and fittings	[r] 1,098,345	174,156	1,653,209	256,955
Angles, shapes and sections	[r] 1,625,488	[r] 159,197	2,194,004	205,466
Tinplate and terneplate	156,351	27,112	227,663	39,156
Rails and railway track material	20,256	1,853	34,216	3,105
Wire	[r] 663,713	[r] 133,270	825,456	162,088
Castings and forgings	[r] 16,475	[r] 7,516	12,029	5,576
Total	[r] 11,457,973	[r] 1,319,830	17,853,995	1,989,482
Grand total	[r] 11,485,587	[r] 1,326,280	17,893,537	1,999,088

[r] Revised.

Table 16.—World production of pig iron (including ferroalloys), by countries[1]

(Thousand short tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada	6,717	7,261	7,400	7,108	8,550
Mexico (includes sponge iron)	1,291	1,325	1,595	1,830	2,228
United States	87,922	91,016	94,000	89,479	91,345
South America:					
Argentina	666	751	[r] 600	686	623
Brazil	[r] 2,984	[r] 2,637	[r] 3,288	3,435	3,753
Chile	494	355	491	560	487
Colombia	226	225	186	228	219
Peru [2]	30	22	[r] 13	34	NA
Venezuela	356	368	387	465	677
Europe:					
Austria	2,434	2,429	2,424	2,363	2,733
Belgium	8,870	9,222	9,072	9,912	11,432
Bulgaria	504	766	[r] 995	[e] 1,050	[e] 1,050
Czechoslovakia	[r] 6,301	6,468	6,910	7,520	7,600
Denmark	79	83	90	83	[e] 83
Finland	[r] 653	[r] 1,030	1,030	1,121	1,154
France	[r] 17,288	[r] 17,383	[r] 17,185	17,317	18,409
Germany:					
East [2]	2,491	2,577	2,698	2,783	2,572
West	29,963	29,751	28,013	30,166	33,406
Hungary	1,653	1,753	[r] 1,822	[2] 1,824	[2] 1,806
Italy	3,996	6,207	7,074	8,228	8,812
Luxembourg	4,620	4,569	4,367	4,365	[e] 4,400
Netherlands	2,147	2,606	2,435	2,853	3,110
Norway [2]	482	578	694	702	750
Poland	6,220	6,349	6,455	7,254	7,539
Portugal	[r] 297	304	274	314	319
Rumania	2,121	2,226	2,423	2,707	3,298
Spain	2,170	2,653	[r] 2,464	3,047	3,170
Sweden	2,569	2,708	2,648	[e] 2,797	3,003
Switzerland	35	30	30	26	31
U.S.S.R. [3]	68,759	72,955	77,453	82,466	86,862
United Kingdom	19,347	19,555	17,595	16,971	18,403
Yugoslavia	1,184	1,295	1,342	1,297	1,418
Africa:					
Algeria	4	7	[e] 11	[e] 11	[e] 11
Rhodesia, Southern	351	276	287	NA	NA
South Africa, Republic of	3,182	3,972	[r] 4,042	4,177	4,546
Tunisia	-------	---------	[e] 55	108	141
United Arab Republic	212	[r] 209	[r] 237	[e] 237	NA
Asia:					
China, mainland [e]	19,800	20,900	22,000	15,400	20,900
India	[r] 7,426	[r] 7,851	7,981	7,785	8,071
Japan	[r] 26,938	[r] 31,033	[r] 36,126	45,227	52,306
Korea:					
North	1,477	[e] 1,600	[e] 1,650	[e] 1,930	[e] 2,200
South [2]	8	29	47	[e] 34	19
Taiwan	68	79	78	95	84
Thailand	6	6	2	7	[e] 44
Turkey [4]	442	551	906	934	1,003
Oceania: Australia	4,463	4,755	5,295	5,575	6,141
Total [5]	[r] 349,246	[r] 368,725	[r] 382,170	392,511	424,708

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Pig iron is also produced in the Congo (Kinshasa), but quantity produced is believed to be negligible.

[2] Excluding ferroalloys.

[3] U.S.S.R. in Asia included with U.S.S.R. in Europe.

[4] Includes foundry iron.

[5] Total is of listed figures only.

Table 17.—World production of steel ingots and castings, by countries

(Thousand short tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada	9,128	10,068	10,003	9,694	11,251
Mexico	2,593	2,743	[r] 3,031	[r] 3,373	3,621
United States [1]	127,076	131,462	134,101	127,213	131,462
South America:					
Argentina	1,394	1,508	1,397	1,462	1,711
Brazil	[r] 3,325	[r] 3,288	[r] 4,169	[r] 4,074	4,890
Chile	644	526	636	696	628
Colombia	254	267	239	278	292
Peru	90	104	88	88	116
Uruguay	15	14	11	15	10
Venezuela	485	689	592	735	828
Europe:					
Austria	3,521	3,551	3,520	3,332	3,822
Belgium	9,624	10,107	9,829	10,710	12,661
Bulgaria	524	648	772	[e] 772	[e] 830
Czechoslovakia	9,234	9,478	[r] 10,057	[r] 11,025	11,600
Denmark	437	454	446	438	462
Finland	409	400	440	434	772
France	21,501	21,319	21,589	21,666	22,498
Germany:					
East	[r] 4,246	[r] 4,288	[r] 4,502	[r] 4,677	4,822
West	41,159	40,588	38,929	40,536	45,370
Greece	231	231	231	176	240
Hungary	2,607	2,778	2,919	3,019	3,200
Ireland	[r] 58	[r] 73	[r] 60	72	74
Italy	10,795	13,978	15,034	17,516	18,700
Luxembourg	5,025	5,054	4,839	4,939	5,823
Netherlands	2,924	3,468	3,598	3,760	4,086
Norway	677	745	805	872	908
Poland	9,450	10,018	10,858	11,524	12,133
Portugal	265	289	284	333	345
Rumania	3,350	3,777	4,045	4,505	5,237
Spain	3,472	3,876	4,241	5,064	5,532
Sweden	4,899	[r] 5,211	[r] 5,249	5,256	5,616
Switzerland	380	380	472	489	499
U.S.S.R. [2]	[r] 93,738	100,833	106,822	112,683	117,947
United Kingdom	29,378	30,252	27,233	26,760	28,962
Yugoslavia	1,849	1,950	2,058	2,019	2,201
Africa:					
Algeria	22	NA	18	19	19
Rhodesia, Southern	141	143	143	NA	NA
South Africa, Republic of	3,463	[r] 3,575	[r] 3,576	4,038	4,431
Tunisia	-------	---------	[e] 50	[e] 50	88
United Arab Republic	194	197	215	220	NA
Asia:					
China, mainland [e]	15,400	16,500	17,600	12,100	16,500
India	[r] 6,709	[r] 7,132	[r] 6,710	[r] 7,091	[e] 7,068
Japan	43,871	45,372	52,673	68,513	73,736
Korea:					
North	1,248	[e] 1,360	[e] 1,430	[e] 1,600	[e] 1,930
South	184	209	237	353	401
Pakistan	13	13	14	99	110
Taiwan	331	485	331	276	[e] 280
Turkey	536	734	1,035	1,164	1,222
Oceania: Australia	5,563	6,021	6,493	6,835	7,096
Total [3]	[r] 482,432	[r] 505,656	[r] 523,624	542,563	581,519

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Data from American Iron and Steel Institute. Excludes production of castings by companies that do not produce steel ingots.

[2] U.S.S.R. in Asia included with U.S.S.R. in Europe.

[3] Total is of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—192-741/100

Iron and Steel Scrap

By John W. Thatcher [1]

The domestic ferrous scrap industry staged a moderate comeback in 1968, due primarily to a 6-percent increase in the production of ferrous castings and a 3-percent increase in the production of raw steel. Sales and total consumption of iron and steel scrap increased from the previous year's levels; however, record low prices at midyear resulted as steel mills reduced scrap inventories in favor of increasing inventories of steel products as a hedge against the threat of a basic steel strike on August 1. New electric furnace capacity under construction in 1968 was welcomed by scrap processors, as scrap consumption in open-hearth furnaces continued a downward trend. The Bureau of Mines was active in research projects designed to expedite reuse of junked automobiles.

Table 1.—Salient iron and steel scrap, and pig iron statistics in the United States

(Thousand short tons)

	1967	1968
Stocks Dec. 31:		
Scrap at consumer plants	7,793	7,882
Pig iron at consumer and supplier plants	2,842	2,342
Total	10,635	10,224
Consumption:		
Scrap	85,361	87,060
Pig iron	87,371	89,953
Imports for consumption, scrap (including tinplate scrap)	229	294
Exports, iron and steel scrap	[r] 7,506	6,565
Price: Scrap, No. 1 heavy-melting, Pittsburgh, average per long ton [1]	$26.68	$26.67
Value: Scrap, all grades, for export [2]	$36.61	$33.61

[r] Revised.
[1] Iron age.
[2] As computed from export data obtained from the Bureau of the Census.

AVAILABLE SUPPLY

During 1968, iron and steel scrap consumers had 87.1 million short tons available at their plants, an increase of 2.5 percent over the quantity available during the preceding year. Although net supply increased, the portions provided by purchased and home scrap remained unchanged from 1967 at 38.5 percent and 61.5 percent, respectively.

CONSUMPTION

Domestic scrap consumption, primarily a function of steel production, was at the third highest level in the history of the consuming industries, exceeded only by 91.5 million tons consumed in 1966, and 90 million tons consumed in 1965, both record steel-producing years. Although the consumption of scrap in 1968 increased almost 2 million tons above that of 1967, the scrap proportion of total ferrous metallics charged to ironmaking, steelmaking, and ferroalloy furnaces decreased from 49.4 percent in 1967 to 49.2 percent in 1968. This small percentage decrease represents about 425,000 tons of scrap replaced by pig iron in ferrous melting and refining operations. The downward trend in relative use of scrap, which began in 1966, may be illustrated by the following example: If scrap and pig iron had been used in 1968 in the same proportion as that used in 1965, scrap consumption in 1968 would have been higher by 2.1 million tons, or the ferrous metallic equivalent of about 2.1 million junk automobiles.

---

[1] Physical scientist, Division of Mineral Studies.

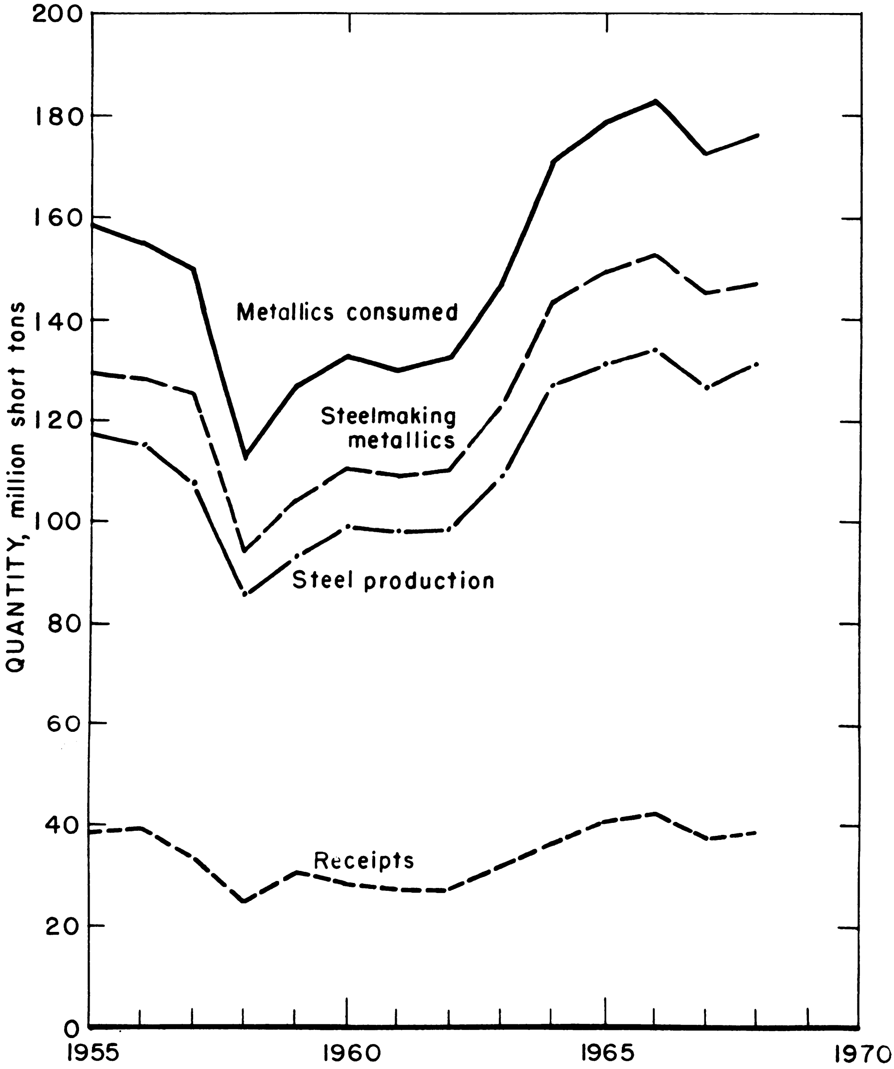

Figure 1.—Metallics consumed—Total iron and steel scrap plus pig iron; Steelmaking metallics—Total iron and steel scrap plus pig iron consumed in steelmaking furnaces; Steel production (AISI); Receipts of purchased scrap by consumers.

STOCKS

Iron and steel scrap stocks held by consumers increased steadily throughout the first 7 months of the year, reaching a high of 8.4 million tons in August. This peak was coincident with the sharp drop in steel production after the basic steel contract settlement on August 1. Stocks gradually fell toward yearend as the rate of steel production increased after September. Stocks of ferrous scrap held by consumers on December 31, 1968, equaled a 33-day supply at an average daily consumption rate of 239,000 tons.

PRICES

The 1968 average composite price of No. 1 heavy melting steel scrap, the industry's prime grade, fell to its lowest level in 22 years despite increased steel production and scrap consumption. The average composite price for No. 2 bundles—old auto bodies—dropped to about $20 per ton at yearend, and prices for turnings and borings were reported to be so low that some processors were charging industrial plants for removal of these grades. Prices at yearend were slightly higher than those for July, but were substantially lower than those at the beginning of the year.

FOREIGN TRADE

International trade in iron and steel scrap benefited the U.S. balance of payments by $192 million, as exports exceeded imports by 6.4 million tons. Exports for the first 7 months of the year were inhibited by the strong domestic demand for scrap as steel mills produced at a record rate; however, a lower domestic demand after the August 1 basic steel settlement coupled with a resurgence of foreign steel production stimulated exports during the remainder of the year. Exports in November attained the highest monthly total since July 1961, due largely to the anticipation of a east and gulf coast dock strike in December. Total exports of ferrous scrap in 1968 decreased about 1 million tons from the near-record level of 1967; a 2-million-ton drop in exports to Japan was partially offset by an increase in exports to Italy, Spain, Taiwan, and other countries. Of the grades of scrap exported, heavy melting steel and baled steel each showed about a 700,000-ton decrease, while other steel scrap (terneplated and tinplated) showed an increase of over 400,000 tons.

Imports of ferrous scrap were dwarfed by exports by a ratio of 1:23, again demonstrating the abundant supply of iron and steel scrap in the U.S. market which is available to both domestic and foreign consumers.

TECHNOLOGY

Ferrous scrap research in both the Federal and the private sectors continued to be focused on the junk auto, the one item in the iron and steel cycle that is most visible, most complex, and most resistant to recycling. The Bureau of Mines' ferrous scrap research program was expanded in scope in 1965 and was designed to develop the necessary technology for converting this resource into a material highly desirable for recycling, thus adding positively to the Nation's mineral base. Bureau projects underway in 1968 were in various stages of development at several centers throughout the country and ranged from the initial reclamation process, that is, auto dismantling, to the final loss of identity of the auto scrap in the steel melt.[2]

A project to design, construct, and operate an experimental, pollution-free, automobile incinerator at the Bureau's Salt Lake City Metallurgy Research Center was well along by yearend. The incinerator is designed to process eight cars per hour and will probably be operational by mid-1969. Also underway was a project to leach out the nonferrous inclusions and components in junk cars that are not removed by incineration. A promising and efficient low-cost modification of the conventional cyclic ammonia leach method for recovering nonferrous metals has been devised.

Methods to upgrade the nonmagnetic rejects from shredding operations are also being studied at the Salt Lake City Center. A procedure which employs air to fluidize and separate the nonmetallic from the metallic portions of the shredded reject material appears promising.

In another study, researchers at Salt Lake City have dissected a number of automobiles as a means of analyzing the complete metallic and nonmetallic content of the units, data which the automobile manufacturers have been unable to provide. Thoroughness of the study is evidenced by the fact that for the larger cars, over 300 parts are removed, classified, and weighed. Time and motion data were obtained using various dismantling methods including cutting torches, hand-stripping, and cut-off saws. Weight distribution data were classified according to location of part and assembly, and according to type of metal. Three tests were completed in 1968, bringing to a total of 17 the junk cars which have been dismantled, weighed, and analyzed. A final report on these studies will be available sometime in the last half of 1969.

---

[2] Melcher, Norwood B. Utilization of Ferrous Scrap. Proc. Symp. on Mineral Waste Utilization, cosponsored by the Bureau of Mines and Illinois Inst. Technol., Res. Inst., Mar. 27–28, 1968, pp. 132–137.

A new use has been developed for ferrous auto scrap at the Salt Lake City Metallurgy Research Center. Shredded scrap has been used in a rotating tumbler for cementation of copper from dump leach solutions. Preliminary cost evaluations indicate this procedure to be economically competitive to the usual tin can precipitation in launders.[3]

Projects at the Bureau's Twin Cities Metallurgy Research Center in Minneapolis, Minn., which were related to the auto scrap research, involved studies on the production of secondary pig iron from mixed off-grade ferrous scrap, including junk cars, and studies on high-temperature oxidation of ferrous scrap to produce iron-oxide and clean scrap products which can be used as a source of iron in the foundry and primary steel industries.

Researchers at the Twin Cities Metallurgy Center have also developed a rapid method for removing copper from high-copper content iron scrap by sweating in a bath of molten slag or stable salt, such as barium chloride. In laboratory tests on motor armatures, well over 90 percent of both copper and iron were recovered after a 2- or 3-minute immersion in the bath. The copper product assayed at more than 98 percent copper, and the steel cores retained from 1 to 4 percent copper. The process appears most feasible for iron or steel scrap with more than 15 percent copper, such as armatures from motors and generators. Research is continuing to test the process on other scrap copper commodities and to devise the hardware and a detailed flowsheet for extrapolating the process to a commercial scale.

At the Bureau's Albany (Oregon) Metallurgy Research Center, investigations were carried out in cooperation with the Esso Research and Engineering Co. to produce carbon steel directly by the continuous addition of prereduced iron ore to molten scrap in an electric furnace. The automobile scrap used consisted of No. 2 bundles, sheared auto hulks, shredded auto hulks, and pig iron produced from auto scrap. Advantages of this process over conventional cold charging techniques are shorter heat time, lower electrical energy consumption, and a purer product by virtue of the purity of the prereduced iron.[4]

A joint contract was signed in February between the Scrap Research Foundation, a research division of the Institute of Scrap Iron and Steel, and the Bureau of Mines for studies on the improvement of scrapyard layout. Research on the project entitled, "Investigations of Efficiency in Scrap Processing Yard Arrangements," is being conducted by Ralph Stone and Company, Los Angles, Calif., and a final report will be prepared in 1969. This was the first joint project undertaken by the Scrap Research Foundation with a Government agency. An earlier project had been undertaken by the Foundation with the Association of American Railroad Car Dismantlers, a group of Institute members specializing in railroad car salvage.

Woodall-Duckham, Ltd., Crawley, England, announced in June that after 7 years' experimental and pilot plant work, the company and its partners, Peace River Mining & Smelting Ltd., of Edmonton, Alberta, Canada, will build a plant near Windsor, Ontario, to produce high-quality iron powder from impure raw materials. The most convenient feedstocks for the process are reported to be pickle liquor (produced by the hydrochloric acid pickling of steel strip) and iron and steel scrap. The plant, which is close to the center of the U.S. automobile industry, will have a capacity of 50,000 tons per year and is expected to go on stream early in 1970. Iron powder has had a growing use in the manufacture of ferrous components, and a large market is envisioned if the production of flat-rolled steel sheet from iron powder proves feasible.

In a recently completed study, General Motors Corporation concluded that the use of "ripper-shredder" system for processing automobile scrap results in a lower and more consistent contamination level than can be obtained using conventional shredding operations. In the General Motors concept, cars enter the system on a wide belt conveyor where exterior trim is manually removed. Then the cars pass through a ripper or presizer where they are torn into eight to 10 pieces. After fragmentation in a shredding mill, the material is discharged onto a screen where fines are removed. Then it is passed over a magnetic separator where nonferrous material is removed. In a scaled-up test, 100 tons of auto scrap was processed in a ripper-shredder system and then melted in a basic oxygen furnace. Copper residuals were 0.16 percent; nickel was 0.08 percent; and chromium was largely oxidized. General Motors engineers believe that copper residuals lower than 0.12 percent can be realistically and consistently achieved on a commercial basis. A cost study of the process indicated that a 13.56-percent return on investment is possible.

---

[3] Dean, Karl C., Rees D. Groves, and Sherman L. May. Copper Cementation Using Automobile Scrap in a Rotating Drum. BuMines Rept. of Inv. 7182, 1968, 12 pp.

[4] Hunter, Willard L., and Gerald W. Elger. Progress Report on the Use of Automobile Scrap and Directly Reduced Iron Ore in Production of Electric Furnace Steel. Proc. Electric Furnace Conf. (AIME), Chicago, v. 25, 1967, pp. 161–164.

Table 2.—Iron and steel scrap supply[1] available for consumption in 1968, by States

(Thousand short tons)

State	Receipts	Production	Total new supply	Shipments[2]	New supply available for consumption
Alabama	1,635	1,868	3,503	266	3,237
Arizona	W	W	W	W	W
Arkansas	W	W	W	W	W
California	1,500	1,401	2,901	84	2,817
Colorado	302	454	756	4	752
Connecticut	80	60	140	4	136
Delaware	W	W	W	---------	W
Florida	W	W	W	---------	W
Georgia	289	98	387	1	386
Illinois	3,859	4,530	8,389	472	7,917
Indiana	2,818	7,676	10,494	1,022	9,472
Iowa	397	201	598	3	595
Kansas	57	36	93	---------	93
Kentucky	779	837	1,616	45	1,571
Louisiana	8	4	12	1	11
Maine	W	W	W	W	W
Maryland	412	2,637	3,049	266	2,783
Massachusetts	47	60	107	3	104
Michigan	4,232	4,328	8,560	113	8,447
Minnesota	195	234	429	23	406
Mississippi	W	W	W	---------	W
Missouri	874	270	1,144	6	1,138
Montana	W	W	W	W	W
Nebraska	W	W	W	W	W
Nevada	W	---------	W	---------	W
New Hampshire	W	W	W	---------	W
New Jersey	550	156	706	15	691
New York	1,467	2,548	4,015	62	3,953
North Carolina	173	43	216	---------	216
Ohio	7,707	9,101	16,808	1,304	15,504
Oklahoma	182	54	236	---------	236
Oregon	W	W	W	W	W
Pennsylvania	7,371	12,178	19,549	1,799	17,750
Rhode Island	90	58	148	2	146
South Carolina	W	W	W	W	W
Tennessee	235	173	408	12	396
Texas	1,495	1,500	2,995	104	2,891
Utah	97	873	970	15	955
Vermont	15	9	24	---------	24
Virginia	W	W	W	W	W
Washington	370	114	484	8	476
West Virginia	W	W	W	W	W
Wisconsin	443	523	966	95	871
Undistributed	1,784	1,521	3,305	147	3,158
U.S. total[3]	39,463	53,545	93,008	5,876	87,132

W Withheld to avoid disclosing individual company confidential data, included in undistributed.

[1] New supply available for consumption is a net figure computed by adding production to receipts and deducting scrap shipped, during the year. The plus or minus difference in stock levels at the beginning and end of year is not taken into consideration.

[2] Includes scrap shipped, transferred or otherwise disposed of during the year.

[3] Data may not add to totals due to independent rounding.

Table 3.—Consumption of iron and steel scrap and pig iron[1] in the United States in 1968, by type of consumer and type of furnace or equipment

(Thousand short tons)

Type of furnace or equipment	Manufacturers of steel ingots and castings[2]		Manufacturers of steel castings[3]		Iron foundries and miscellaneous users		Total all types[4]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Blast furnace[5]	4,267	--------	-------	-------	--------	-------	4,267	--------
Basic oxygen converter[6]	16,112	39,284	-------	-------	--------	-------	16,112	39,284
Open-hearth furnace	31,127	40,072	492	73	--------	-------	31,619	40,145
Electric furnace	16,342	415	1,965	34	1,243	70	19,550	519
Cupola furnace	1,804	298	480	6	12,492	2,605	14,776	2,909
Other furnaces[7]	374	178	61	18	301	77	736	273
Total[4]	70,026	80,248	2,998	131	14,036	2,752	87,060	83,131

[1] Excludes molten pig iron used for ingot molds and direct castings.
[2] Includes only those castings made by companies producing steel ingots.
[3] Excludes companies that produce both steel ingots and steel castings.
[4] Data may not add to totals shown due to independent rounding.
[5] Includes consumption in all blast furnaces producing pig iron.
[6] Includes scrap and pig iron processed in metallurgical blast cupolas and used in oxygen converters.
[7] Includes air, induction and vacuum melting furnaces, and Bessemer converters.

Table 4.—Proportion of iron and steel scrap and pig iron used in furnaces in the United States

(Percent)

Type of furnace	1968	
	Scrap	Pig iron
Basic oxygen converter	29.1	70.9
Open-hearth furnace	44.0	56.0
Electric furnace	97.4	2.6
Cupola furnace	83.6	16.4
Other furnaces[1]	72.9	27.1

[1] Includes air, induction and vacuum melting furnaces, and Bessemer converters.

Table 5.—Consumption of iron and steel scrap and pig iron[1] by States, by type of manufacturers in 1968

(Thousand short tons)

State	Steel ingots and castings[2]		Steel castings[3]		Iron foundries and miscellaneous users		Total[4]	
	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Alabama	2,222	3,175	116	(5)	1,021	594	3,359	3,769
Arizona	W	-------	W	-------	W	-------	W	W
Arkansas	-------	-------	W	-------	-------	-------	W	-------
California	2,481	2,111	106	2	262	75	2,849	2,188
Colorado	693	980	19	(5)	43	(5)	755	980
Connecticut	57	-------	3	(5)	77	22	137	22
Delaware	W	W	W	(5)	W	W	W	W
Florida	W	-------	-------	-------	-------	-------	W	W
Georgia	347	-------	6	(5)	30	11	383	11
Illinois	6,444	4,628	526	14	1,124	130	8,094	4,772
Indiana	8,625	12,209	147	1	656	183	9,428	12,393
Iowa	-------	-------	48	(5)	556	54	604	54
Kansas	-------	-------	77	(5)	16	2	93	2
Kentucky	1,334	1,559	-------	-------	258	33	1,592	1,592
Louisiana	-------	-------	13	(5)	-------	-------	13	(5)
Maine	-------	-------	-------	-------	W	(5)	W	(5)
Maryland	2,752	5,636	21	-------	87	5	2,860	5,641
Massachusetts	-------	-------	15	(5)	84	31	99	31
Michigan	5,133	6,715	61	1	3,205	490	8,399	7,206
Minnesota	242	424	57	(5)	93	37	392	461
Mississippi	W	-------	-------	-------	-------	-------	W	-------
Missouri	868	-------	95	5	86	19	1,049	24
Montana	-------	-------	-------	-------	W	W	W	W
Nebraska	-------	-------	W	(5)	W	-------	W	(5)
Nevada	-------	-------	W	(5)	-------	-------	W	(5)
New Hampshire	-------	-------	W	(5)	W	-------	W	(5)
New Jersey	253	(5)	51	1	383	79	687	81
New York	3,062	5,389	145	14	707	89	3,914	5,492
North Carolina	102	-------	-------	-------	106	37	208	37
Ohio	12,673	14,345	359	40	2,147	180	15,179	14,566
Oklahoma	170	-------	20	(5)	44	14	234	14
Oregon	W	-------	W	(5)	W	-------	W	(5)
Pennsylvania	16,630	17,873	407	38	709	126	17,745	18,037
Rhode Island	89	8	-------	-------	49	11	138	19
South Carolina	-------	-------	-------	-------	46	W	46	W
Tennessee	-------	-------	18	2	374	125	392	127
Texas	2,170	1,116	75	(5)	564	81	2,809	1,197
Utah	W	W	W	W	W	W	W	W
Vermont	-------	-------	-------	-------	23	6	23	6
Virginia	-------	-------	161	W	471	W	632	W
Washington	476	7	20	1	10	-------	506	8
West Virginia	1,700	W	32	W	51	W	1,783	W
Wisconsin	-------	-------	265	7	585	158	850	165
Undistributed	1,503	4,073	135	3	169	160	1,807	4,236
U.S. total[4]	70,026	80,248	2,998	131	14,036	2,752	87,060	83,131

W Withheld to avoid disclosing individual company confidential data, included in undistributed.

[1] Excludes molten pig iron used for ingot molds and direct castings.

[2] Includes only those castings made by companies producing steel ingots.

[3] Excludes companies that produce both steel ingots and steel castings.

[4] Data may not add to totals shown due to independent rounding.

[5] Less than ½ unit.

Table 6.—Consumption of iron and steel scrap and pig iron[1] in the United States in 1968, by State, by furnace

(Thousand short tons)

State	Blast furnace	Basic oxygen converter		Open-hearth furnace		Electric furnace		Cupola furnace		Other furnaces[2]	
	Scrap	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron	Scrap	Pig iron
Alabama	179	W	W	W	W	425	1	990	597	(3)	-----
Arizona	-----	-----	-----	-----	-----	W	-----	-----	-----	W	-----
Arkansas	-----	-----	-----	-----	-----	W	-----	-----	-----	-----	-----
California	W	W	W	1,337	W	845	27	273	73	W	-----
Colorado	W	W	W	W	W	52	(3)	13	W	W	-----
Connecticut	-----	-----	-----	-----	-----	64	2	47	12	25	9
Delaware	-----	-----	-----	W	W	W	-----	-----	-----	-----	-----
Florida	-----	-----	-----	-----	-----	W	W	-----	-----	-----	-----
Georgia	-----	-----	-----	-----	-----	W	-----	29	11	W	-----
Illinois	375	842	1,452	2,301	3,168	3,179	19	1,300	121	97	13
Indiana	310	2,500	6,269	5,468	5,932	477	4	646	178	26	10
Iowa	-----	-----	-----	-----	-----	245	W	358	42	W	W
Kansas	-----	-----	-----	-----	-----	77	(3)	16	2	-----	-----
Kentucky	W	W	W	W	W	595	-----	168	149	W	-----
Louisiana	-----	-----	-----	-----	-----	W	-----	W	(3)	-----	-----
Maine	-----	-----	-----	-----	-----	-----	-----	W	(3)	-----	-----
Maryland	W	W	W	W	W	W	W	108	6	W	-----
Massachusetts	-----	-----	-----	-----	-----	22	(3)	73	29	3	2
Michigan	357	2,474	5,964	W	W	611	10	4,084	541	W	-----
Minnesota	W	-----	-----	W	W	42	(3)	108	87	-----	-----
Mississippi	-----	-----	-----	-----	-----	W	-----	-----	-----	-----	-----
Missouri	-----	-----	-----	W	W	935	(3)	72	19	-----	-----
Montana	-----	-----	-----	-----	-----	-----	-----	-----	-----	W	W
Nebraska	-----	-----	-----	-----	-----	W	(3)	W	-----	-----	-----
Nevada	-----	-----	-----	-----	-----	W	(3)	-----	-----	-----	-----
New Hampshire	-----	-----	-----	-----	-----	W	(3)	W	-----	-----	-----
New Jersey	-----	-----	-----	-----	-----	388	W	287	67	W	W
New York	337	W	W	W	W	249	7	638	89	W	-----
North Carolina	-----	-----	-----	-----	-----	W	(3)	105	37	-----	-----
Ohio	1,266	2,768	7,007	4,834	7,100	3,663	84	2,529	213	119	162
Oklahoma	-----	-----	-----	-----	-----	194	W	40	11	-----	-----
Oregon	-----	-----	-----	-----	-----	W	(3)	W	-----	W	-----
Pennsylvania	1,046	2,693	6,191	9,221	11,609	3,671	64	860	119	254	53
Rhode Island	-----	-----	-----	W	W	W	(3)	49	11	-----	-----
South Carolina	-----	-----	-----	-----	-----	W	-----	W	W	-----	-----
Tennessee	-----	-----	-----	-----	-----	42	8	350	119	-----	-----
Texas	W	-----	-----	980	853	1,304	247	454	97	-----	-----
Utah	W	-----	-----	W	W	W	W	W	W	W	-----
Vermont	-----	-----	-----	-----	-----	-----	-----	23	6	-----	-----
Virginia	-----	-----	-----	-----	-----	193	W	437	W	W	-----
Washington	-----	-----	-----	-----	-----	500	8	6	(3)	-----	-----
West Virginia	W	W	W	W	W	W	W	W	W	W	W
Wisconsin	-----	-----	-----	W	W	260	5	497	137	56	18
Undistributed	897	4,835	12,401	7,478	11,483	1,517	33	216	186	156	6
U.S. total[4]	4,267	16,112	39,284	31,619	40,145	19,550	519	14,776	2,909	736	273

W Withheld to avoid disclosing individual company confidential data, included in undistributed.

[1] Excludes molten pig iron used for ingot molds and direct castings.

[2] Includes air, induction and vacuum melting furnaces, and Bessemer converters.

[3] Less than ½ unit.

[4] Data may not add to totals shown due to independent rounding.

Table 7.—Receipts, production, consumption, shipments and stocks of iron and steel scrap and pig iron, by type of manufacturer, in 1968

(Thousand short tons)

	Manufacturers of steel ingots and castings [1]	Manufacturers of steel castings [2]	Iron foundries and miscellaneous users	Total
Scrap:				
Receipts	28,650	2,000	8,818	39,468
Production	46,639	1,166	5,740	53,545
Consumption by grades:				
Carbon steel:				
Low-phosphorus plate and punchings	388	768	731	1,887
Cut structural and plate	333	190	932	1,455
No. 1 heavy melting steel	26,439	272	307	27,018
No. 2 heavy melting steel	2,707	6	167	2,880
No. 1 and electric furnace bundles	6,893	78	449	7,420
No. 2 and all other bundles	3,489	29	538	4,056
Turnings and borings	2,096	73	569	2,738
Slag scrap (Fe content)	3,255	5	22	2,282
Shredded or fragmentized	572	39	89	700
All other carbon steel scrap	14,308	920	1,575	16,803
Stainless steel	815	29	34	878
Alloy steel (except stainless)	2,685	131	133	2,949
Cast iron (includes borings)	5,737	323	8,063	14,123
Other grades of scrap	309	135	427	871
Total consumption	70,026	2,998	14,036	87,060
Shipments	5,150	166	560	5,876
Stocks Dec. 31	6,691	346	845	7,882
Pig iron:				
Receipts	4,940	132	3,532	8,604
Production	88,050	------	------	88,050
Consumption	86,270	133	3,550	89,953
Shipments	7,117	------	2	7,119
Stocks Dec. 31	2,028	22	292	2,342

---

[1] Includes only those castings made by companies producing steel ingots.
[2] Excludes companies that produce both steel ingots and castings.

Table 8.—Consumer stocks of iron and steel scrap, by grades, and pig iron, Dec. 31, 1968, by States

(Thousand short tons)

State	Carbon steel (excludes rerolling rails)	Stainless steel	Alloy steel (excludes stainless)	Cast iron (includes borings)	Other grades of scrap	Total scrap stocks	Pig iron stocks
Alabama	227	(1)	(1)	54	1	282	808
Arizona	W	-------	W	W	W	W	-------
Arkansas	W	-------	-------	-------	-------	W	-------
California	222	(1)	3	86	(1)	311	21
Colorado	21	-------	1	2	1	25	6
Connecticut	5	3	(1)	5	(1)	13	3
Delaware	W	W	W	W	W	W	W
Florida	W	-------	-------	-------	W	W	-------
Georgia	32	-------	-------	1	-------	33	1
Illinois	882	3	14	85	1	985	236
Indiana	783	10	6	84	8	891	40
Iowa	46	(1)	-------	4	(1)	50	3
Kansas	4	-------	-------	(1)	-------	4	(1)
Kentucky	106	1	13	4	-------	124	11
Louisiana	1	-------	-------	-------	-------	1	(1)
Maine	W	-------	-------	W	-------	W	W
Maryland	125	11	9	29	(1)	174	28
Massachusetts	2	(1)	(1)	3	-------	5	3
Michigan	318	12	3	92	2	427	134
Minnesota	52	-------	1	6	1	60	21
Mississippi	W	-------	-------	-------	-------	W	-------
Missouri	142	(1)	1	17	2	162	4
Montana	-----	-------	-------	W	-------	W	W
Nebraska	W	-------	-------	W	-------	W	-------
Nevada	W	-------	-------	W	-------	W	W
New Hampshire	W	-------	-------	-------	-------	W	W
New Jersey	43	(1)	1	33	(1)	77	23
New York	374	13	10	79	(1)	476	336
North Carolina	13	-------	-------	7	-------	20	2
Ohio	866	26	65	121	6	1,084	580
Oklahoma	32	-------	-------	1	1	34	3
Oregon	W	W	W	W	-------	W	W
Pennsylvania	1,249	43	213	244	18	1,767	430
Rhode Island	14	-------	1	1	(1)	16	2
South Carolina	W	W	-------	W	-------	W	W
Tennessee	8	-------	-------	6	1	15	6
Texas	197	(1)	5	20	(1)	222	20
Utah	212	-------	6	40	-------	258	47
Vermont	1	-------	-------	2	-------	3	(1)
Virginia	20	-------	(1)	8	-------	32	17
Washington	82	(1)	1	4	1	88	14
West Virginia	73	-------	1	7	-------	81	5
Wisconsin	32	(1)	(1)	13	1	46	34
Undistributed	95	3	6	10	6	116	4
U.S. total [2]	6,279	125	360	1,068	50	7,882	2,342

W Withheld to avoid disclosing individual company confidential data, included in undistributed.

[1] Data may not add to totals shown due to independent rounding.

[2] Less than ½ unit.

Table 9.—Consumer stocks, receipts, production, consumption, and shipments of iron and steel scrap in 1968, by grades

(Thousand short tons)

Grades of scrap	Receipts	Production	Total consumption	Shipments	Stocks Dec. 31
Steel scrap:					
Carbon	32,262	40,371	68,239	4,133	6,279
Stainless	376	558	878	43	125
Alloy, excludes stainless	601	2,521	2,949	111	360
Cast iron, including borings	5,885	9,362	14,123	1,383	1,068
Other grades of scrap	339	733	871	206	50
Total	39,463	53,545	87,060	5,876	7,882

Table 10.—Stocks of iron and steel scrap and pig iron at major consuming industries plants, Dec. 31

(Thousand short tons)

Year	Manufacturers of steel ingots and castings	Manufacturers of steel castings	Iron foundries and miscellaneous users	Total
Scrap stocks:				
1967	6,538	342	913	7,793
1968	6,691	346	845	7,882
Pig iron stocks:				
1967	2,433	25	384	2,842
1968	2,028	22	292	2,342

Table 11.—Average monthly price and composite price for No. 1 heavy melting scrap in 1968

(Per long ton)

Month	Chicago	Pittsburgh	Philadelphia	Composite price [1]
January	32.10	32.90	30.50	31.83
February	31.00	33.25	30.25	31.50
March	27.00	31.50	28.75	29.08
April	24.80	26.50	27.30	26.20
May	23.88	25.50	25.50	24.96
June	22.50	23.50	24.50	23.50
July	21.70	23.50	24.50	23.24
August	21.50	23.50	25.50	23.50
September	21.90	24.50	25.30	23.90
October	21.50	24.50	24.50	23.50
November	23.13	24.50	24.50	24.04
December	23.90	26.30	24.50	24.90
Average:				
1968	24.57	26.67	26.30	25.85
1967	28.47	26.63	27.79	27.62

[1] Composite price, Chicago, Pittsburgh, Philadelphia.

Source: Iron Age, Jan. 12, 1969.

Table 12.—U.S. exports of iron and steel scrap, by countries

Destination	Iron and steel scrap including tinplate and terneplate scrap				Rerolling material			
	1967		1968		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	22,317	$737	221	$30	------	------	------	------
Australia	3,045	89	49	2	------	------	------	------
Belgium-Luxembourg	2,322	201	20,574	769	------	------	------	------
Brazil	858	20	208	7	------	------	------	------
Canada	542,373	14,800	523,442	12,106	1,132	$55	142	$27
Colombia	5,145	175	5,214	174	------	------	------	------
Denmark	6,775	133	41	14	------	------	------	------
France	13,851	494	14,820	1,634	------	------	------	------
Germany, West	1,477	222	57,857	2,952	------	------	------	------
Greece	---------	------	9,150	194	------	------	------	------
Hong Kong	409	214	8,081	546	------	------	------	------
Italy	217,139	5,401	728,615	20,363	------	------	------	------
Japan	5,300,261	173,259	3,386,515	92,223	19,211	816	9,937	343
Korea, South	306,757	10,773	304,181	10,003	91,928	3,846	100,819	4,729
Mexico	747,280	25,754	528,289	18,074	8,783	425	9,470	447
Netherlands	962	64	4,634	255	------	------	------	------
Pakistan	24	4	22,068	456	------	------	------	------
Peru	20	1	5,789	234	------	------	------	------
Philippines	11,819	289	19,103	451	------	------	------	------
Spain	85,472	1,634	357,393	7,664	------	------	------	------
Sweden	27,943	4,200	104,763	16,068	------	------	------	------
Taiwan	85,260	2,973	195,093	5,336	15,651	686	6,641	298
Thailand	12,022	380	47,081	1,323	------	------	------	------
Turkey	28,977	770	77,917	1,940	------	------	------	------
United Arab Republic	63,986	1,938	29,888	668	------	------	------	------
United Kingdom	1,370	135	2,657	268	------	------	------	------
Venezuela	17,608	516	29,813	783	25,748	105	------	------
Vietnam, South	197	16	129	37	------	------	------	------
Yugoslavia	---------	------	69,586	1,889	------	------	------	------
Other	692	111	11,878	542	------	------	------	------
Total	[r] 7,506,361	245,303	6,565,049	197,005	162,453	5,933	127,009	5,844

[r] Revised.

Table 13.—U.S. exports and imports for consumption of iron and steel scrap by classes

(Thousand short tons and thousand dollars)

Class	1967		1968	
	Quantity	Value	Quantity	Value
Exports:				
Nos. 1 and 2 heavy melting steel scrap	3,913	$122,429	3,265	$92,670
Nos. 1 and 2 baled steel scrap	r 1,903	45,808	1,239	26,150
Borings, shovelings, and turnings	462	9,009	439	8,359
Iron scrap	447	12,777	416	10,868
Rerolling material	162	5,933	127	5,844
Other steel scrap (terneplated and tinplated)	782	55,280	1,206	58,958
Total	r 7,669	251,236	6,692	202,849
Imports:				
Iron and steel scrap	216	8,181	276	10,784
Tinplate scrap	14	381	18	541
Total	229	8,562	294	11,325

r Revised.

Table 14.—U.S. imports for consumption of iron and steel scrap, by countries

Country	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	112	$42	22	$7
Belgium-Luxembourg	---------	---------	1,961	501
Canada	215,276	7,075	279,404	9,781
French West Indies	---------	---------	2,148	69
Germany, West	4	2	1,655	60
India	499	287	11	6
Italy	21	10	1,115	310
Mexico	382	27	764	74
Netherlands	166	91	---------	---------
New Zealand	16	7	---------	---------
Norway	17	29	822	28
Rumania	11,010	286	---------	---------
Sweden	---------	---------	236	66
United Kingdom	1,557	653	5,996	399
Other	102	53	91	24
Total	229,162	8,562	294,225	11,325

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/62

Iron Oxide Pigments

By John W. Thatcher[1]

Sales of pure synthetic iron oxides continued to show strong growth as established applications for ferrite devices expanded and new applications appeared on the threshold of widespread use. Domestic sales and demand for iron oxide pigments were at alltime high levels.

Table 1.—Salient iron oxide pigments statistics in the United States

	1964	1965	1966	1967	1968
Mine production……short tons..	59,300	57,000	63,200	39,900	57,600
Crude pigments sold or used……do…	59,700	56,200	63,900	41,800	57,600
Value……thousands..	$446	$419	$476	$326	$457
Finished pigments sold……short tons..	119,500	127,500	130,700	127,300	132,400
Value……thousands..	$22,991	$23,549	$24,841	$26,720	$30,676
Exports……short tons..	5,100	4,700	4,800	3,100	3,300
Value……thousands..	$1,817	$1,380	$1,307	$1,312	$1,257
Imports for consumption……short tons..	16,300	17,800	24,600	23,400	29,900
Value……thousands..	$1,817	$2,165	$3,163	$3,203	$4,117

DOMESTIC PRODUCTION

Iron oxide pigment producers benefited in 1968 from the general improvement of business in domestic basic industries as evidenced by a 44-percent increase in mine production of crude iron oxide pigment material and increases in sales for most grades of iron oxide pigments. Crude material was mined by six companies in six States and sold by seven companies in six States. Finished iron oxide pigments were sold by 12 companies with 17 plants in nine States.

CONSUMPTION AND USES

Sales of finished oxide pigments in the United States in 1968 reached a record high of 132,400 tons, a 4-percent increase over those of the previous year. Overall value of sales by U.S. processors jumped 15 percent to $30.7 million, due in part to price increases that went into effect at midyear. Sales of natural iron oxide pigments decreased 2 percent, while sales of synthetic iron oxide pigments increased 9 percent. Pure synthetic iron oxides were used as paint pigments but were also ideal as starting material in ferrite production. Ferrite applications included use in radio antennas, electric motors, magnetic switches, memory devices, computers, recorders, microwave equipment, and certain types of transformers.

Data are not collected by the Bureau of Mines on specific uses of iron oxide pigments, and the figures given in table 2 do not necessarily reflect all sales of iron oxide pigment material for uses except as pigments.

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Finished oxide pigments sold by processors in the United States, by kinds

Pigment	1967		1968	
	Short tons	Value [1] (thousands)	Short tons	Value [1] (thousands)
Natural:				
Brown:				
Iron oxide (metallic)[2]	12,881	$2,226	14,245	$2,558
Umbers:				
Burnt	3,802	789	3,877	849
Raw	667	135	1,063	231
Red:				
Iron oxide	[3] 34,752	[3] 2,060	28,199	1,607
Sienna, burnt	1,164	387	896	318
Pyrite cinder	(3)	(3)	3,949	262
Yellow:				
Ocher [4]	4,654	262	4,759	275
Sienna, raw	600	174	639	194
Total natural	58,520	6,033	57,627	6,294
Manufactured:				
Black: Magnetic	3,781	1,654	3,560	1,185
Brown: Iron oxide	4,792	2,466	6,177	3,622
Red:				
Pure red iron oxides:				
Calcined copperas	19,486	5,635	18,910	5,604
Other chemical processes [5]	12,109	3,462	14,838	4,111
Venetian red	670	104	594	99
Yellow: Iron oxide	23,177	6,664	25,670	7,455
Total manufactured	64,015	19,986	69,749	22,076
Unspecified including mixtures of natural and manufactured red iron oxides	4,803	700	5,007	2,306
Grand total	127,338	26,720	132,383	30,676

[1] Data may not add to totals shown because of independent rounding.
[2] Includes some black magnetite and vandyke brown.
[3] Pyrite cinder included with red iron oxide for 1967.
[4] Includes some yellow iron oxide.
[5] Includes other manufactured red iron oxides.

PRICES

Price increases of some types of iron oxide pigments were announced in May, effective June 3, by a major domestic producer. Price advances for raw sienna ranged from 0.75 to 1.00 cent per pound; for burnt siennas, from 0.5 to 1.25 cents per pound; and for some synthetic brown oxides, as much as 1.00 cent per pound. Prices for other iron oxide pigments were essentially unchanged. The price ranges shown in table 3 reflect variations which may be due to differences in quantity, quality, locality, or individual suppliers' views.

Table 3.—Prices quoted on finished iron oxide pigments, per pound, in bags, unless otherwise noted, as of December 31, 1968

Pigment	Low	High	Pigment	Low	High
Black:			Red:		
Pure	$0.1475	$0.1650	Domestic primers	$0.0658	$0.0658
Synthetic	.1275	.1300	Persian Gulf [1]	.0700	.0750
Brown:			Pure synthetic	.1525	.1650
Pure, synthetic	.1550	.1750	Spanish, docks, New York [1]	.0550	.0625
Metallic	.0625	.0750	Sienna, burnt	.1100	.1200
Umber, American, burnt [1]	.0775	.1150	Yellow:		
Umber, American, raw [1]	.0925	.1100	Ocher, domestic	.0300	.0425
Vandyke: American [1]	.1075	.1100	Ocher, French type	.0675	.0725
Sienna, American, burnt [1]	.1600	.2150	Pure, light lemon	.1325	.1525
			Other shades [1]	.1250	.1375

[1] Barrels.

Source: Oil, Paint and Drug Reporter, American Paint Journal, and pigment processors.

FOREIGN TRADE

The United States exported iron oxide pigments to 49 countries in 1968. Export tonnage was up 6 percent in 1968; however, value dropped 4 percent. The average value of exports was 18.9 cents per pound, compared with 21.0 cents in 1967, and 13.7 cents in 1966. Exports to Canada, which in recent years had accounted for over 50 percent of the total, continued to decline, while shipments to France, West Germany, Japan, Mexico, United Kingdom, and Venezuela showed increases over those for 1967.

Imports of iron oxide pigments increased 27 percent in 1968, reaching an alltime high and accounting for 13.5 percent of total sales to domestic consumers. Although imports of most types of natural pigments increased somewhat, a 32-percent increase in imports of synthetic pigments was largely responsible for the record import total.

Of the ochers imported to the United States, 116 short tons of ground pigment came from the Republic of South Africa and 10 tons of crude or washed ocher came from Spain. Cyprus supplied 517 tons of crude sienna while Italy supplied 840 tons of crude and 21 tons of washed sienna. Imports of ground sienna, by country of origin, were as follows: Italy, 55 tons; United Kingdom, 22 tons; and Cyprus, 9 tons. Cyprus, the Republic of South Africa, and the United Kingdom supplied 3,821, 328, and 10 tons, respectively, of crude umbers to U.S. consumers in 1968. Additionally, Cyprus and the United Kingdom supplied 362 and 150 tons of ground umbers, respectively. Imports of Vandyke brown were made up of 538 tons from West Germany and 51 tons from Spain.

Sixty-two percent of the synthetic iron oxide pigments imported were supplied by West Germany, 33 percent by Canada, 5 percent by the United Kingdom, with the remainder from France, Belgium-Luxembourg, Japan, and Spain.

Table 4.—U.S. exports of iron-oxide pigments, by countries

Destination	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	97	$47	63	$39
Australia	328	189	326	169
Belgium-Luxembourg	10	6	17	6
Brazil	58	35	99	59
Canada	976	354	871	250
Chile	5	3	16	5
Colombia	10	4	15	7
France	143	63	200	80
Germany, West	467	166	541	164
Greece	27	17	--------	--------
Guatemala	37	10	49	13
India	10	4	19	6
Italy	31	12	30	17
Japan	98	36	148	65
Mexico	28	17	111	94
Netherlands	72	85	96	14
New Zealand	27	6	55	9
Panama	14	4	1	1
Philippines	90	34	85	31
Sweden	3	1	19	11
United Kingdom	199	79	262	99
Venezuela	106	29	122	39
Vietnam, South	164	48	46	22
Other countries	123	63	130	57
Total	3,123	1,312	3,321	1,257

Table 5.—U.S. imports for consumption of selected iron-oxide pigments

Pigments	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Natural:				
Ocher, crude and refined	236	$16	126	$8
Siennas, crude and refined	951	104	1,464	178
Umber, crude and refined	4,275	162	4,671	178
Vandyke brown	272	24	589	50
Other [1]	3,670	271	4,442	253
Total	9,404	577	11,292	662
Manufactured (synthetic)	14,034	2,626	18,596	3,455
Grand total	23,438	3,203	29,888	4,117

[1] Classified by the Bureau of the Census as "Natural iron-oxide and iron-hydroxide pigments, n.s.p.f."

Table 6.—U.S. imports for consumption of iron-oxide and iron-hydroxide pigments, n.s.p.f. by countries

Country	Natural				Synthetic			
	1967		1968		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousnads)	Short tons	Value (thousands)
Belgium-Luxembourg	-------	-------	7	$9	-------	-------	18	$2
Canada	73	$4	-------	-------	4,494	$969	6,052	1,275
France	55	5	(1)	1	-------	-------	80	12
Germany, West	-------	-------	5	5	8,660	1,513	11,453	2,018
Iran	-------	-------	276	10	-------	-------	-------	-------
Italy	10	1	-------	-------	-------	-------	-------	-------
Japan	-------	-------	(1)	(1)	1	1	17	2
Netherlands	10	1	-------	-------	72	15	-------	-------
Spain	3,244	225	3,866	196	24	2	3	1
United Kingdom	278	35	288	32	783	126	973	145
Total	3,670	271	4,442	253	14,034	2,626	18,596	3,455

[1] Less than ½ unit.

TECHNOLOGY

Research and development in the iron oxide pigment industry was concerned mainly with improving existing pigment types and production techniques. Technologic efforts were directed toward a better control of both size and shape of pigment particles; toward an improved brightness and color reproducibility; toward better dispersion and coverage; and toward more sophisticated manufacturing methods to provide higher purity products. The development of special pigment modifications which are "tailor-made" for special vehicles and specific applications continued in 1968.

The production of synthetic iron oxide pigment from scrap iron and sulfuric acid was described. Northern Pigment Company, Ltd., of Toronto, Canada, reacts scrap iron with sulfuric acid and air during an 8-week cooking period, producing about 200 tons of high-purity iron oxide per batch. The product is used principally in making ferrite cores, although some of it is sold as dry color to the paint and construction industries.[2]

---

[2] American Metal Market. Canadian Company Finds Bonanza in Scrap Iron. V. 75, No. 189, Oct. 1, 1968, p. 18.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/43

Kyanite and Related Minerals

By John W. Sweeney [1]

Sales of domestic kyanite concentrate declined 2 percent in 1968, and was 3 percent below the record production of 1966. However, due to a price increase in 1968, value for kyanite sold or used set a record high. A kyanite-sillimanite mixture was recovered from a Florida heavy mineral operation. Combustion Engineering, Inc., acquired the Mullite Corporation of America's facilities at Andersonville, Ga. The demand for refractories made predominately from synthetic mullite continued the downward trend paralleling the declining demand for most other types of refractories. Output of synthetic mullite was 11 percent lower than that of 1967, but the value increased 20 percent.

Kyanite, sillimanite, andalusite, dumortierite, topaz, and synthetic mullite are included in this chapter because all are aluminum silicates with similar properties and are used to produce mullite refractories.

DOMESTIC PRODUCTION

Demand for kyanite was at a slightly lower level in 1968. Total output of domestic kyanite concentrate decreased about 4 percent, while that sold or used by producers declined about 2 percent. Crude ore production decreased 9 percent, but the ratio of concentrate to ore increased slightly. Production figures are withheld to avoid disclosing individual company confidential data. Kyanite was produced by three companies from four mines in 1968; Commercialores, Inc., Clover, S.C., and Aluminum Silicates, Inc., Lincolnton, Ga., both subsidiaries of Combustion Engineering, Inc.; and Kyanite Mining Corp., with mines near Farmville and Dillwyn, Va. A Florida heavy minerals producer recovered a kyanite-sillimanite concentrate from tailings.

Bayer process alumina and silica sand, siliceous bauxite and bauxite mixtures were the raw materials used in the production of high purity synthetic mullite. Other mullite products were made from siliceous bauxite and bauxite-clay mixtures. Electrically fused mullite was produced in electric arc furnaces, and sintered mullite was made in rotary, periodic, and tunnel kilns. The following firms reported production in 1968:

The Babcock & Wilcox Co., Refractories Division, New York, N.Y. (plant at Augusta, Ga.)
The Carborundum Co., Niagara Falls, N.Y. (plant at Niagara Falls, N.Y.)
General Abrasive Co., Inc., Niagara Falls, N.Y. (plant at Niagara Falls, N.Y.)
Harbison-Walker Refractories Co., Pittsburg, Pa. (plant at Eufaula, Ala.)
Norton Co., Worcester, Mass. (plant at Huntsville, Ala.)
H. K. Porter Co., Inc., Refractories Division, Pittsburgh, Pa. (plant at Shelton, Conn.)
Remmey Division of A. P. Green Fire

Table 1.—Synthetic mullite production in the United States

Year	Short tons	Value (thousands)
1964	36,108	$4,450
1965	40,049	4,866
1966	49,551	5,961
1967	40,288	4,811
1968	36,014	5,758

---

[1] Mining engineer, Knoxville Office of Mineral Resources, Knoxville, Tenn.

Brick Co., Philadelphia, Pa. (plant at Philadelphia, Pa.)

The Chas. Taylor Sons Co., subsidiary of National Lead Co., Cincinnati, Ohio (plant at South Shore, Ky.)

Combustion Engineering, Inc., acquired the Mullite Corporation of America's facilities at Andersonville, Ga., and was in the process of enlarging the plant to produce synthetic mullite from bauxite and kaolin. Initial production is planned for mid-1969.

CONSUMPTION AND USES

All domestically produced kyanite was minus 35-mesh or finer material and was used principally in refractory mortars, ramming mixes, and plastic refractories. Synthetic mullite made predominantly of fused bauxite, and fused or dense-sintered alumina, was used mostly for producing extra-high alumina brick and shapes. Significant quantities were used in other refractories and special ceramics.

Most of the kyanite and mullite in the United States was used in refractory applications, with the iron and steel industry being the major consumer. The amount of mullite used in glass furnaces was considerable, but this use was declining. Portions of iron blast furnace stoves and stacks were lined with mullite in preference to other refractories because of mullite's longer service life, lower installation cost, and resistance to spalling, slagging, and chemical reaction. Other important uses of kyanite and mullite included kiln linings and kiln furniture and linings for frit and enameling furnaces. Small quantities of kyanite and mullite were used in ceramic and glass mixes, foundry mold facings, lightweight aluminum silicate wool insulation, ceramic honeycomb, and other specialty items. Some potential uses may be in brake linings, grinding balls, and welding rod coatings.

The use of kyanite in ceramic products is beneficial in a number of ways. Workability is often improved, which in turn increases production rates and reduces losses due to processing defects. The growth of interlocking mullite crystals in the products during the firing process increases their strength.

PRICES

Domestic kyanite prices were increased by $8 a ton effective February 1, 1968. The new carload lot prices were as follows:

Domestic kyanite, short ton, f.o.b. Virginia and South Carolina:

35-mesh, carload lots, bulk	$55
35-mesh, carload lots, bags	$58
48-mesh, carload lots, bags	$60
100-mesh, carload lots, bags	$61
200-mesh, carload lots, bags	$66
325-mesh, carload lots, bags	$86

Published prices for imported kyanite, 60 percent grade, increased $7 c.i.f. Atlantic ports, according to the Engineering and Mining Journal for December 1968, and ranged from $86 to $91 per short ton.

The f.o.b. prices for Georgia kyanite were approximately the same as those quoted for Virginia and South Carolina material. Prices for the Florida material were somewhat lower. An extra charge of $12 per ton was made by most domestic producers for conversion of kyanite to mullite.

FOREIGN TRADE

Exports of material classified as kyanite and allied minerals, including mullite, decreased 4 percent in quantity and 7 percent in value from 1967 levels. This decline is mainly attributed to decreased purchases by Canada, Japan, and the United Kingdom. Previously, however, exports of these materials had been increasing at an average annual rate of about 35.5 percent since 1962. This overall increase in kyanite exports has been due in large part to the decline in the Republic of South Africa's output of high quality sillimanite. Refractory manufacturers in 29 countries throughout the world purchased kyanite and mullite produced in the United States. The major importing countries were Japan, Canada, and West Germany.

Continuing a decline that began in 1951, domestic imports of kyanite fell 20 percent in 1968, and imports reached the lowest point since kyanite import statistics first became available in 1937. Indian kyanite accounted for 96 percent of the volume and value, and the balance was supplied by the Republic of South Africa.

Table 2.—U.S. exports and imports for consumption of kyanite and related minerals

	1966		1967		1968	
	Short tons	Value	Short tons	Value	Short tons	Value
EXPORTS						
Argentina	------	-----------	24	$2,236	22	$1,420
Australia	1,291	$96,036	393	28,328	704	46,748
Belgium-Luxembourg	234	19,842	582	52,448	876	61,464
Canada	4,270	316,619	5,012	337,954	3,861	252,084
Colombia	103	7,590	--------	-----------	182	11,566
France	92	8,675	291	51,037	398	49,074
Germany, West	1,072	60,144	1,492	87,958	1,740	104,527
Italy	587	39,934	1,564	120,887	1,557	116,490
Japan	5,150	327,335	7,143	427,477	5,576	331,262
Mexico	1,581	91,386	1,610	110,706	1,488	88,987
Netherlands	145	5,819	60	2,280	61	3,990
South Africa, Republic of	13	707	37	8,181	144	8,404
Sweden	147	5,789	169	6,935	575	27,082
Thailand	------	-----------	34	2,368	582	35,973
United Kingdom	2,205	121,608	2,414	111,498	1,687	79,481
Venezuela	365	18,702	291	15,816	621	39,675
Other countries	134	10,589	312	47,333	453	52,472
Total	17,339	1,130,725	21,428	1,408,442	20,477	1,310,694
IMPORTS						
India	3,404	$140,145	1,821	$75,158	1,391	$49,414
South Africa, Republic of	1	660	--------	-----------	59	1,967
Total	3,405	140,805	1,821	75,158	1,450	51,381

WORLD REVIEW

Australia.—During the first half of 1968, sillimanite production was 1,300 short tons; in the same period 777 tons of kyanite and sillimanite was imported. For 1967, the last full year for which data are available, sillimanite output was 1,324 tons, a decrease of 56 percent below 1966 production. Imports of kyanite and sillimanite in 1967 totaled 2,560 tons.

Canada.—North American Refractories Company of Cleveland, Ohio, completed construction of mining and processing facilities near Tamiskaming, Quebec, that have production capacity of 12,000 tons of kyanite concentrates per year. Initial production is slated for 1969.

India.—Kyanite production was 55,527 tons in 1967 compared with 70,183 tons in 1966. Exports increased by 5,181 tons over that of 1966 to 44,480 tons, establishing a new record. Eighty percent of the 1967 production was exported, 16 percent was consumed on the domestic market, and 4 percent was in pithead and consumer stocks at yearend. Exports in 1967 from the famous "Lapso Baru" deposit were mainly to European countries. Domestic demand for the kyanite-type mullite refractories was increasing, but kyanite exports still remain an important earner of foreign exchange.

Sillimanite output was 6,390 tons in 1967 compared with 11,338 tons in 1966. Of this, exports totaled 2,247 tons, and the remainder was used in domestic production of refractories.

Reserves of kyanite deposits in the Dahegaon-Pardi area of Maharashtea, described by the Geological Survey of India, were estimated at about 10.8 million tons. Both kyanite and sillimanite occur in the same deposits.[2]

Korea, South.—Output of andalusite and kyanite was 73 tons in 1967 compared with 51 tons in 1966.

---

[2] Industrial Minerals (London). World of Minerals. No. 5, February 1968, p. 22.

Liberia.—A report published by the Liberian Geological Survey described the Mount Montro Kyanite Deposit, Grand Bassa County.[3] The deposit, a large single body in a belt approximately 12,600 feet long, 480 feet wide, and from 25 to 350 feet thick, has a kyanite content ranging from 10 to 35 percent. Total reserves were estimated at about 10 million tons of kyanite rock containing about 2.5 million tons of kyanite.

South Africa, Republic of.—Sillimanite production for the first 9 months of 1968 was 27,663 tons with output indicated to be slightly lower than that of 1967. Andalusite production for the same period was 18,826 tons, and if the trend continued for the rest of the year, would indicate a considerable decline below 1967 production. For this 9-month period, about 70 percent of the total output was exported. In 1967, the last full year for which data are available, sillimanite output was 39,005 tons, a slight increase over 1966 output. Andalusite production rose to 27,098 tons compared with 23,684 tons for 1966.

TECHNOLOGY

Bureau of Mines research showed the applicability of heavy liquid separation techniques for recovery of concentrates from minus 35-mesh ore samples of kyanite, potash, spodumene, fluorspar, and beryl.[4] Known resources of high-temperature refractory raw materials in the Pacific Northwest were substantially increased by the completion of Bureau of Mines field and laboratory studies of kyanite group mineral deposits. A study of present and potential domestic and foreign markets for western kyanite will be published in 1969.

The calcination and sintering behavior of three samples of Alabama bauxitic material was studied in the laboratory.[5] At 2,700°F the densification of the three samples—two mainly of mullite and siliceous glass, and the third mullite and cristobalite—stopped and the pellets reached their maximum bulk specific gravity.

The first American edition of a comprehensive British report on the sillimanite group minerals and synthetic mullite was published.[6] The work describes the minerals, refractory qualities and specifications, information on deposits throughout the world (including reserves where available), mining and processing methods, world trade, prices and uses. In addition to a discussion of synthetic mullite production, an extensive bibliography broken down into major subject headings is included.

---

[3] Stanin, S. Anthony, and Bismark R. Cooper. The Mount Montro Kyanite Deposit, Grand Bassa County, Liberia. Republic of Liberia. Bureau of Natural Resources and Surveys, Geological Survey. Bull. No. 2, 1968, 20 pp.

[4] Tippin, R. B., and James S. Browning. Heavy Liquid Cyclone Concentration of Minerals (in Two Parts). 2. A study of Liquid Cyclone Concentration of Various Mineral Systems. BuMines Rept. of Inv. 7134, 1968, 53 pp.

[5] Bakker, Walter T. General Refractories Research Project Reveals Higrade Domestic Bauxite. Brick and Clay Record, v. 153, No. 7, August 1968, pp. 24–26.

[6] Varley, E. R. Sillimanite (Andalusite, Kyanite, Sillimanite). First American Edition, Chemical Publishing Co., Inc., New York, 1968, 165 pp.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/168

Lead

By Donald E. Moulds [1]

The world lead industry achieved a record level of production and consumption in 1968. World mine production indicated at 3.31 million tons was closely alined with metal production at 3.22 million tons, a significant upward surge of 4.4 percent from the 1967 level. The free world mine production of 2.44 million tons and smelter production of 2.38 million tons did not satisfy the indicated 5.3-percent increase in metal consumption. Producer stocks, after a buildup in midyear to some 204,000 tons at the end of July, ended the year at 163,000 tons, about 18,000 tons below that existing at the end of 1967. The foreign lead price reflected the tightening supply situation with a gradual rise in the monthly average from 9.94 cents per pound (U.S. equivalent) for January to 11.28 cents for December.

The domestic industry, after a slow start in 1968 due to the continued strike closure of some mining and primary smelting facilities during the first quarter, quickly recovered and mine production reached 359,200 tons, the largest since 1952; primary metal output of 467,300 tons was last exceeded in 1958. Delays caused by strikes, startup difficulties, and lack of trained personnel at the new mines and smelters in Missouri, however, prevented realization of the expected major increase in mine and smelter output in 1968.

Table 1.—Salient lead statistics

	1964	1965	1966	1967	1968
United States:					
Production:					
Domestic ores, recoverable lead content...short tons..	286,010	301,147	327,368	316,931	359,156
Value...thousands..	$74,936	$93,959	$98,964	$88,741	$94,903
Primary lead (refined):					
From domestic ores and base bullion...short tons..	294,254	305,007	318,646	258,507	349,039
From foreign ores and base bullion...short tons..	155,175	113,242	122,089	121,387	118,271
Antimonial lead (Primary lead content)...short tons..	8,607	6,612	11,182	9,083	19,494
Secondary lead (Lead content) short tons..	541,582	575,819	572,834	553,772	550,879
Exports of lead materials excluding scrap short tons..	10,194	7,811	5,435	6,536	8,281
Imports, general:					
Lead in ores and matte...do....	123,257	122,661	143,991	124,067	87,836
Lead in base bullion...do....	4,838	566	2,012	752	150
Lead in pigs, bars, and old short tons..	212,898	226,883	293,085	373,887	344,601
Stocks December 31 (lead content):					
At primary smelters and refineries short tons..	84,398	83,443	115,473	125,479	90,427
At consumer plants...do....	113,444	109,195	90,306	105,786	88,900
Consumption of metal, primary and secondary...short tons..	1,202,138	1,241,482	1,323,877	1,260,516	1,328,790
Price: New York, common lead, average, cents per pound...	13.62	16.00	15.12	14.00	13.21
World:					
Production:					
Mine...short tons..	2,779,182	2,969,939	3,141,583	3,169,108	3,309,057
Smelter...do....	2,818,265	2,911,104	3,020,486	3,057,553	3,220,977
Price: London, common lead, average, cents per pound...	12.59	14.37	11.87	10.28	10.88

---

[1] Physical scientist, Division of Mineral Studies.

Reported domestic consumption, marked by a record output of storage batteries and gasoline additives, established a new high of 1.33 million tons, almost 5½ percent above the 1967 total and slightly above the previous high of 1.32-million tons set in 1966. Despite the increase in smelter metal and the continued high level of metal imports and secondary metal, stocks were depleted and all of the Government stockpile lead authorized for disposal was sold by early April. The available lead supply for the year, (production, imports, secondary stock changes and exports) indicated a disappearance of some 92,000 tons of lead in addition to the 1.32 million tons reported as consumed, well above the indicated disappearance in recent years.

The domestic price of lead, stable at the 14 cents per pound level established on October 10, 1966, was decreased to 13 cents on May 2, 1968, and 12½ cents on July 15, reflecting the expected supply surplus after settlement of the 9-month strike in April, and also a slight buildup of stocks during the normal vacation doldrums of July and August. Continued high consumption, both domestic and foreign, and strike diminished supply, however, resulted in a stock drawdown and on October 11 a price increase to 13 cents per pound was initiated and joined by all producers on October 14.

The situation at the end of the year was one of high demand, stocks amounting to less than 1 month's consumption, no stockpile lead authorized for sale, and a rising European price of 11.3 cents per pound, well above the normal 2½ to 3 cents per pound comparative domestic differential.

Legislation and Government Programs.—The price of lead throughout 1968 was below the 14.5 cents per pound floor under which payments to eligible domestic producers are authorized by "The Lead and Zinc Mining Stabilization Program," Public Law 89–239. Payments in 1968 amounted to $98,889 on 5,876 tons of lead. Under the revised regulations, published June 1, 1966, 60 producers of the 142 applying were certified. Under this program initiated in October 1961, total payments on 36,801 tons of eligible lead have amounted to $1,251,618 and on combined lead and zinc $2,520,023. Oklahoma and Utah had the largest number of active participants in the program, each with 24, although Oklahoma has received the largest payment, amounting to 43 percent of the total.

Government participation in exploration, primarily for lead, was withdrawn in June 1962. The program, under the Office of Minerals Exploration, Department of the Interior, continued active in other base metals—antimony, bismuth, copper, gold, and silver. These metals are often in association with lead and the national lead resource is benefited by the work performed with government assistance.

Sales of Government stockpile surplus lead under Public Law 89–9 enacted in March 1965, was conducted by General Services Administration on an open-sale, shelf-item basis until early April. Sales were terminated at that time upon completion of the 150,000 tons total authorized for commercial sale. Sales amounted to 26,460 tons and deliveries to 28,677 tons for the calendar year, thus reducing the Government inventory to 1,164,603 tons of refined lead valued at $302.8 million. The Government inventory also contained an additional 10,336 tons of antimonial lead valued at $3.1 million.

The International Lead and Zinc Study Group held its 12th session in Geneva, Switzerland, on November 18–22, preceded on November 13–15 by meetings of various committees concerned with statistics, form and estimates of production and consumption, and factors influencing trade in lead and zinc. Representatives of 27 countries attended the session, including the Republic of Zambia and the Hungarian Peoples Republic which were formally accepted into membership. The Study Group noted the lower than expected mine and metal production, the import of some 55,000 tons of lead from free world markets by China, and a rise of about 5½ percent in metal consumption. The conclusion of the statistical committee was a supply shortfall of 20,000 tons in 1968 and an indicated statistical supply surplus in 1969.

The International Lead-Zinc Research Organization, incorporated in 1965 by 26 charter member companies, has grown to 31 companies in 11 countries representing the majority of the world's lead and zinc production. The organization continued to sponsor research and development programs related to basic data and applications for lead and zinc products.

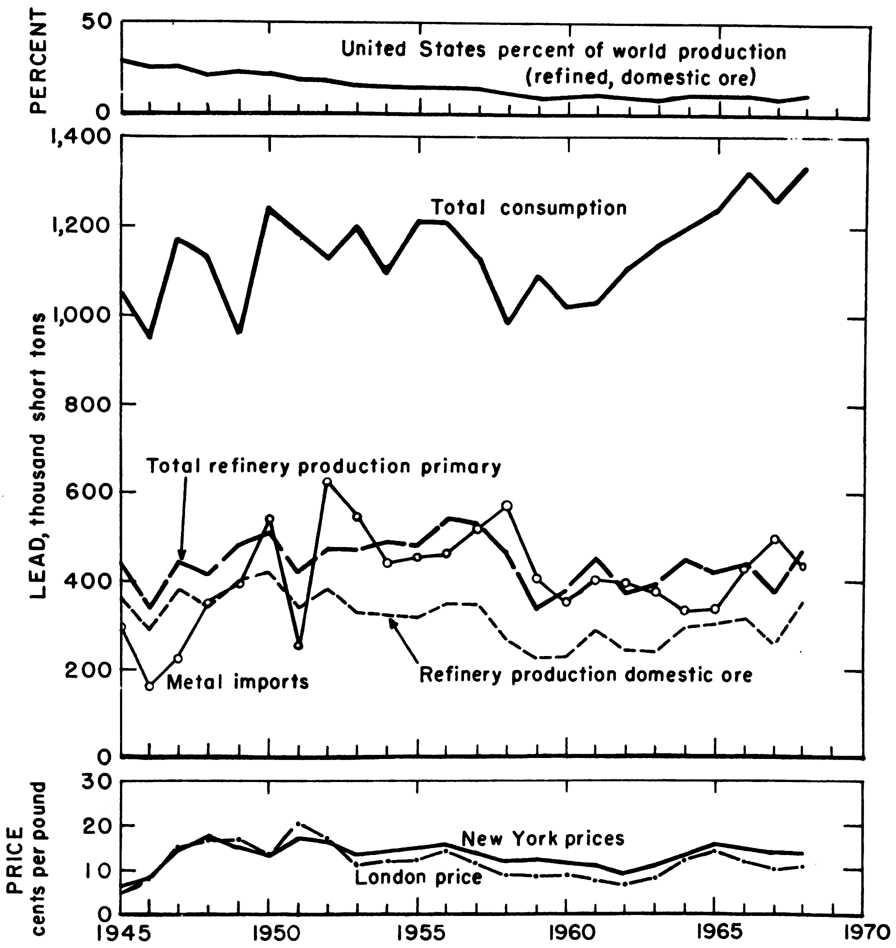

Figure 1.—Trends in the lead industry in the United States.

DOMESTIC PRODUCTION

MINE PRODUCTION

Mine production was curtailed during the first quarter of the year by the continuation of the strike closure of mines in the Western States and inability of other mines to market concentrates due to smelter closures. Operations were resumed in April at most of these mines but normal production levels were not achieved until June. The first 6-month output thus totaled 147,500 tons in comparison to 168,900 tons in the like period of 1967. Production for the year amounted to 359,200 tons, a gain of 42,200 tons (13 percent) over that achieved in 1967. The only significant gain, however, was in Missouri with an output of 212,600 tons, an increase of 60,000 tons. California, Kansas, Montana, Virginia, and Washington also increased output but the remaining lead producing States showed declines in production. The most severe tonnage reduction occurred in Idaho and Utah as a result of strikes at the Lucky Friday and Galena mines in Idaho and

United Park City and Tintic mines in Utah. The continuing shortage of labor, and particularly experienced miners, has affected production and development in most of the domestic mining areas.

Missouri mines accounted for almost 60 percent of the domestic production compared with 48 percent in 1967, followed by Idaho, 14 percent; Utah, 13 percent; and Colorado, 6 percent. These four States contributed 93 percent of the domestic output of recoverable lead in ore and the 25 leading mines listed in table 5 produced 93 percent of the recoverable lead.

Southeast Missouri continued to be the world's most active lead producing area. St. Joseph Lead Co. continued production at the Federal, Indian Creek, Viburnum, and Fletcher mines and concentrators and produced 259,500 tons of lead concentrates in comparison with 220,100 tons in 1967. The new Goose Creek shaft was completed and in production with ore from this development processed at the Indian Creek concentrator. The large, mobile equipment in use at the Fletcher mine has achieved production rates almost six times the maximum level attained with 1958 equipment and methods.[2] This has resulted in positioning the Fletcher as the leading domestic lead mine. The Magmont mine, a joint venture of Cominco American Inc., and Dresser Industries, Inc., was brought into production in midyear and will be at its full capacity of 50,000 tons of lead in concentrates by mid-1969. Reserves at this mine are estimated at 15 million tons of ore containing 1.3 million tons of lead and zinc.[3] The startup of the Missouri Lead Operating Co., a joint venture of American Metal Climax Inc. and Homestake Mining Co., was delayed by extensive underground water flow but was expected to be operational early in 1969. Reserves at this mine are stated to be 53.6 million tons of ore averaging 6 percent lead and zinc.[4] Ozark Lead Co., a subsidiary of Kennecott Copper Corp., continued development at the Ellington mine but was delayed by the strike and lack of experienced personnel.[5]

Development and exploration in the Coeur d'Alene area of Idaho continued to the extent of labor availability. Participation agreements involving American Smelting and Refining Company, Day Mines Inc., Hecla Mining Co., The Bunker Hill Co., and various other property owners have permitted extensive programs of exploration and development in depth in areas adjacent to the Galena mine, Lucky Friday mine, and Sunshine mine. Shaft sinking and development at the Lucky Friday, Sunshine Unit area and Star-Morning Unit area was underway at depths ranging down to the 7,300-foot level at the Star-Morning. The Galena mine resumed operations in April and the Lucky Friday on June 15 after strike closure for 8 months. Operations at The Bunker Hill Co. mines and those operated by Day Mines Inc. were not affected by the strike in 1968.

The Utah mines were also affected by the strike and by a shortage of labor which reduced production. The Midval Flotation Mill, operated by United States Smelting, Refining and Mining Co., was idle for several short periods during the first 4 months, due to shortage of ores from shippers, and stockpiled lead concentrates until resumption of operation at the Tooele, Utah smelter.[6] The Burgin mine of Kennecott Copper Corp. virtually completed construction of a concentration plant and mine expansion from 500 to 800 tons per day. A new shaft to extend the mining area was started in June.

The Idarado mine of Newmont Mining Corp. in Colorado operated all year with a slightly lower output of ore and metal compared with 1967 and development of ore reserves was slightly below ore produced. Development by Resurrection Mining Co. at Leadville, Colo., a joint project of Newmont and American Smelting and Refining Company, has indicated reserves of 2.4 million tons of ore with an average of 5.13 percent lead, 9.95 percent zinc, and 2.65 ounces of silver per ton.[7]

The Pend Oreille Mines & Metals Co. operated the Pend Oreille mine on a more selective mining program and while tonnage was reduced 32 percent, lead produced in concentrates was almost three times larger than in 1967.[8]

---

[2] St. Joseph Lead Co. Annual Report. 1968, p. 9.

[3] Cominco Ltd. Annual Report. 1968, p. 9.

[4] American Metal Climax Inc. Annual Report. 1968, p. 13.

[5] Kennecott Copper Corp. Annual Report. 1968, p. 12.

[6] United States Smelting, Refining and Mining Co. Annual Report. 1968, p. 11.

[7] Newmont Mining Corp. Annual Report. 1968, p. 8.

[8] Pend Oreille Mines & Metals Co. Annual Report. 1968, pp. 4–5.

SMELTER AND REFINERY PRODUCTION

Primary plant production of lead metal amounted to 495,900 tons, an increase of 24 percent compared with the 1967 figure. The strike at plants operated by American Smelting and Refining Company and International Smelting & Refining Co., which began in July 1967, extended through March, but operations were finally resumed in April after settlement. In January production amounted to 18,100 tons, the lowest output since November 1959. A high level of output was, however, regained in March because of the accumulation of lead concentrates at some mines and custom mills during the strike.

The Herculaneum smelter of St. Joseph Lead Co., after a short shutdown in January to effect repair and adjustment after the smelter expansion completed in 1967, produced a record 170,799 tons of refined lead and lead in alloys and again was the leading domestic plant. A sulfuric acid plant was under construction to utilize gases from the smelter.[9]

The Buick, Mo., smelter operated by Missouri Lead Operating Co., a joint subsidiary of American Metal Climax, Inc., and Homestake Mining Co., began initial operations in August on concentrates from the Magmont mine at Bixby, Mo., a 50,000-ton-annual-capacity mine-mill complex owned by Cominco American and Dresser Industries. Production proceeded until November 6 when closed by a strike of the United Steelworkers Union. Settlement was reached on November 20 on a 3-year labor contract and production resumed.[10]

American Smelting and Refining Company's new Glover, Mo., smelter was completed and limited production initiated in July. A strike, however, closed the plant on September 10 after limited shipments were made and operations were not resumed in 1968.[11] The East Helena, Mont., El Paso, Tex., and Selby, Calif., smelters were operated after settlement of the strike and the lead bullion refined at Omaha, Neb., and Selby, Calif.

The lead smelter and refinery at Kellogg, Idaho, operated by The Bunker Hill Co., a subsidiary of Gulf Resources and Chemical Corp., operated at capacity and produced 1.5 percent more metal than in 1967, thus, continuing an expansion in output initiated in 1965. A new updraft sintering facility was installed and waste gases piped to the acid plant for sulfur recovery.[12] The United States Smelting Lead Refinery, Inc., plant at East Chicago, Ind., a subsidiary of United States Smelting, Refining and Mining Co., operated throughout the year although at a low level because the smelter at Tooele, Utah, which produces bullion for refining was closed by the strike.[13] Schuylkill Products Co. also operated smelting and refining facilities during 1968 using a combination of primary and secondary feed materials.

Secondary lead output decreased for the third successive year to 550,900 tons, with that produced at primary plants down 1,200 tons and other plants down 1,700 tons in comparison with 1967. The major change in output was in the class of metal produced with a significant shift toward hard lead. Soft lead comprised 25 percent compared with 27 percent in 1967. Antimonial lead increased to 56 percent compared with 52 percent and other alloys 19 percent (21 percent in 1967). Secondary lead contributed 53 percent of domestic lead production and 40 percent of new supply in 1968 compared with 59 percent and 42 percent in 1967 and 56 percent and 44 percent in 1966. Plants reporting secondary production in 1968 consisted of 173 smelters, including five primary plants, and 21 manufacturers and foundries.

Raw Material Source.—Domestic ores contributed the largest tonnage and percentage of primary smelter feed since 1950. The 364,800 tons of domestic lead in ores in refined and antimonial lead represented 75 percent of the primary lead material consumed in 1968 in comparison with 68 percent in 1967 and 72 percent in the normal operating year of 1966. Slag continued to decrease as a feed material for both refined lead and antimonial lead at primary plants and in 1968 constituted less than 2 percent of the total feed. Raw materials and material in process at primary plants at the beginning of the year amounted to 150,300 tons, lead content, of which 103,600 tons was primary material, 1,400 tons was scrap, and 45,200 tons was in intermediate process materials. Total stocks increased to 162,000 tons at the end of March but upon resumption of operations at the strike-closed smelters decreased to 125,000 tons at the end of July and then gradually increased to 139,100 tons at yearend, of which 85,200 tons was primary raw material, 2,000 tons was scrap, and 52,000 tons was in process.

---

[9] St. Joseph Lead Co. Annual Report. 1968, p. 9.

[10] American Metal Climax, Inc. Annual Report. 1968, p. 13.

[11] American Smelting and Refining Company Annual Report. 1968, p. 12.

[12] Gulf Resources and Chemical Corp. Annual Report. 1968, p. 7.

[13] United States Smelting, Refining and Mining Co. Annual Report. 1968, p. 12.

Consumption of scrap materials amounted to 725,700 tons, gross weight, in comparison to 726,300 tons in 1967. Battery scrap, however, represented 64 percent in comparison to 62 percent in 1967 and 60 percent in 1966. Recycled drosses and residues increased to 104,000 tons in comparison with 101,100 tons in 1967 and amounted to 14 percent of the secondary materials consumed. Receipts of scrap and consumption were balanced for the entire year. The monthly trend, however, indicated the relationship of weather to receipts of scrap, particularly battery scrap. Stocks increased 7.3 percent in January, 1.1 percent in February and March, and then declined 3.6 percent in April, 10.9 percent in May, were balanced in June, increased 9.2 percent in July (the smelter vacation period), and then decreased about 4 percent monthly until December when stocks increased 12.7 percent. The increasing number of gasoline- and battery-powered units on the highways, airways, and waterways, and in industrial use indicates a promising future supply of worn-out batteries for reprocessing into secondary lead.

CONSUMPTION AND USES

Lead consumption recovered dramatically in 1968 to a new record of 1.33 million tons, an increase of 5.4 percent in comparison to the low level of 1967 and almost 5,000 tons above the previous high reported for 1966. The combined record production of batteries and gasoline antiknock compounds, which are dependent on lead, stimulated the increased demand. Examination of domestic supply sources indicated that metal production, imports, stock changes, and Government disposal during 1968 totaled some 92,000 tons of lead above that accounted for in reported distribution. This disappearance was well above that indicated in recent years and presumably was unreported domestic consumption or stock buildup. Consumption was quite evenly spread throughout the year with the historical low again in July and the historical high in October. The 133,100 tons used in October appeared to be a record exceeding the 126,600 tons in October 1950. The daily average of 3,641 tons compares with 3,453 tons in 1967 and 3,627 tons in 1966.

The lead consumed in metal products, other than batteries, was 364,300 tons, almost identical to that used in 1967. Increases posted for ammunition, brass and bronze, calking lead, piping, sheet and solder, were balanced by decreases in bearings, cable covering, casting, collapsible tubes, foil, terne, and type metal. Ammunition continued the upward trend since 1963 reflecting increased military requirements. Brass mills resumed operation in April after the prolonged copper industry strike which reduced requirements in 1967. Increased calking lead, piping, and sheet consumption indicated the high level of construction, as did the use of lead in vibration and sound control. Areas of diminishing requirements were, in general, in accord with the downward trend established in recent years in these historical applications.

The manufacture of lead-acid storage batteries required a record 514,000 tons, approximately 39 percent of the total and 47,000 tons above that used in 1967. The annual growth of lead used in batteries has averaged over 5 percent since 1958. The battery industry enjoyed a record-breaking year in 1968 according to statistics of the Association of American Battery Manufacturers, Inc. A total of 46.5 million automotive-type batteries were shipped, consisting of 35 million replacement batteries, 11 million installed in new vehicles and 418,300 exported. The replacement battery shipments were almost 7 percent above the previous high in 1963 and original equipment was last exceeded in 1965 while exports were the largest since 1952. This large increase reflected the growing number of motor vehicles registered which approached 97 million at the end of 1967, and included the replacement of original equipment in cars produced in the record year of 1965, and new vehicles produced in 1968, the second highest production in history. The indicated life of a battery in 1967, based on vehicle registration and replacement shipments, was 28.6 months, a continuation of the upward trend since 1963. In addition to the automotive-type batteries, the use of larger capacity industrial batteries steadily increased and required 10 to 15 percent of the total lead in batteries.

The use of lead in antiknock compounds was also at a record 261,900 tons, almost 6 percent above the 1967 use and reflects the increasing mileage driven by gasoline-powered vehicles. The annual growth of lead use, interrupted by the jet fuel replacement of aviation gasoline, has averaged almost 5 percent since 1958 and essentially parallels the growth in battery lead.

The automotive requirements for lead in the near future indicate a continuing upward trend in consumption which will outweigh the stable or declining use of lead in some of its historic uses such as piping, type metal, bearings, cable covering, and paints which are being replaced by competitive materials and/or technological change. The use of lead in vibration and noise control is a promising development and the intensive research and development by industry and the International Lead and Zinc Research Organization is indicative of the effort expended to maintain the competitive position of lead in historical use areas as well as participate in new technological developments for metals.

LEAD PIGMENTS

Lead required for production of pigments and oxides increased to 345,500 tons, all derived from pig lead except 1,500 tons in leaded-zinc oxide from ores. Requirements for white lead and red lead continued to decline and represented only 8.4 percent of the total compared with 10 percent in 1967. Consumption in oxides registered major gains—20 percent for litharge and 7 percent for black oxide—as storage battery output using a large percentage of the oxides reached record levels.

The paint industry used a slightly smaller tonnage of white lead in 1968 and the sharp downward trend in recent years appears to have been stabilized. Various uses not itemized also decreased moderately. Red lead in paints decreased 15 percent while miscellaneous uses held steady in comparison to the year 1967.

The upward trend in use of litharge was resumed in 1968 with a 24-percent increase in tonnage distributed to the various industries. Total annual shipments of litharge have grown from 92,000 tons to 131,000 tons since 1958, a growth rate of 13.5 percent annually. Black oxide, a mixture of litharge and finely divided metallic lead forming the active electrodes in storage batteries, has had a growth rate exceeding 6 percent during the like period to achieve the 218,000 tons produced in 1968.

Prices.—The quoted price of lead pigments after remaining unchanged since mid-October 1966, moved with the changing price of lead in 1968, except for basic carbonate white lead which continued at 20.5 cents per pound, carload lots, freight allowed. The price of red lead, 95 percent Pb_3O_4, in carload lots, at works, was quoted at 16.75 cents per pound until early May when it decreased to 15.75 cents following the 1-cent drop in the price of lead and decreased to 15.25 cents in mid-July following the ½-cent drop in lead. In mid-October the price followed the increase in lead price to 15.75 cents which continued through yearend. The price of litharge, commercial grade, powdered, in carload lots, at works, likewise ranged downward from 16.25 cents in January to 14.75 cents and back to 15.25 cents in unison with the price of lead.

The value of shipments of white lead, red lead, and litharge amounted to $52.8 million in comparison to $46.8 million in 1967 and $56 million in 1966.

Foreign Trade.—Export of lead oxides, pigment grade, including compounds of lead arsenate and other, continued to decline in gross weight and value from 2,600 tons valued at $1.04 million in 1966 to 1,909 tons in 1967 and 1,877 tons in 1968 valued at $770,000. Canada continued to be the leading importer followed by the United Kingdom and France.

Imports for consumption of lead compounds and pigments totaled 32,000 tons valued at $6,952,000. Lead compounds, including lead nitrate, acetate, resinate, orange mineral, and other, amounted to 400 tons valued at $118,600. Lead nitrate accounted for 85 percent of the weight. Belgium-Luxembourg, Republic of South Africa, United Kingdom, Mexico, Netherlands, Japan, and West Germany were the suppliers of lead compounds. Leaded zinc oxide imports amounted to 200 tons valued at $44,300, principally from West Germany followed by Mexico, France, and Canada. Litharge was the largest lead pigment material received amounting to 24,800 tons valued at $5.13 million and Mexico supplied 97 percent and France 2 percent of the total. Red lead imports amounted to 4,400 tons valued at $977,000 with Mexico providing 57 percent, France 25 percent, West Germany 13 percent, and Belgium-Luxembourg, Netherlands, Poland, and Ceylon the remaining 5 percent. White lead imports totaled 2,160 tons valued at $672,400 with the Netherlands, West Germany, and Canada the leading suppliers with 90 percent of the total. Approximately 6 tons of miscellaneous lead pigments valued at $8,200 completed the imports of semiprocessed lead materials.

STOCKS

Lead inventories in the hands of producers and consumers were uncomfortably low throughout the year and represented, at the most, a month's consumption. Primary producer stocks of refined lead and antimonial lead combined, totaled 23,400 tons at the beginning of the year and were reduced to 13,200 tons by the end of the first quarter. A buildup in the second and third quarter brought the combined total to 29,600 tons at the end of August and thereafter a sustained drawdown resulted in the total of 15,300 tons at the end of 1968. Total stocks of lead material physically at primary plants was reported to be 90,400 tons at yearend in comparison to 125,500 tons at the end of 1967. The American Bureau of Metal Statistics reported additional material in transit and a total of 161,900 tons.

Consumer stocks, including secondary smelter stocks, were also drawn down in the first quarter and then rebuilt to 116,000 tons at the end of July. The heavy drawdown in the third and fourth quarter brought the closing stocks to 88,900 tons. Government inventory of lead in stockpile was reduced 28,700 tons during the year with a resulting 1,164,600 tons remaining in refined lead and 10,300 tons of antimonial lead.

PRICES

The last change in the price of lead prior to 1968 occurred on October 10, 1966, when a decrease from 15 to 14 cents per pound at New York, became effective. The price remained stable at 14 cents throughout the strike at Western smelters and a favorable differential of 3.5 to 4 cents per pound of the domestic price in comparison to the London Metal Exchange brought increased metal imports into the domestic market.

Upon resumption of operations after the strike on a high output level, anticipation of a continued high import and additional output from the new Missouri smelters, the price was reduced on May 2 to 13 cents per pound and again on July 15 to 12½ cents per pound. The heavy demand in the third quarter and startup problems in Missouri, however, resulted in a price rise on October 11 to 13 cents which became firm on October 14 and continued through the remainder of the year.

The Canadian price closely followed the domestic price declining from 14 cents to 13 cents during the May–September period and increasing to 13½ cents in October. The London Metal Exchange average monthly price, however, moved steadily upward from a 9.95-cent-per-pound average in January, U.S. equivalent, to a 11.41-cent average in September and after a decline in October increased to an average of 11.35 cents for December.

FOREIGN TRADE

The export market for lead improved in 1968, both in tonnage of refined and in scrap materials, although value was slightly lower in both classes of material. The most significant changes were the large increase in shipment of refined lead to the South American and European areas and also the European demand for lead scrap.

General imports of lead in ores during the first half of the year were at a very low level due to the curtailed operations of domestic smelters and a stockpile of domestic concentrates. The total ore and bullion for domestic processing, 88,000 tons for the year, was the lowest amount landed since 1951. Metal imports, amounting to 338,100 tons, was below that received in 1967 and reflected demand for foreign lead resulting from the strike-curtailed domestic refinery output in the first quarter of 1968.

Ores entered for consumption, duty paid, from Australia, Canada, and Honduras were considerably less than the total general import while Peru entries were approximately double the amount delivered as general imports. The lead in ores imported for consumption in 1968 thus amounted to 96,900 tons, a decrease of 33 percent compared with 1967 figures. Canada, Peru, and Australia were the leading suppliers with a combined 75 percent of the total.

Metal imports for consumption totaled 337,600 tons, a decrease of 7 percent compared with 1967 figures but well above the 1966 imports. Peru was the leading supplier of metal with 22 percent, followed by Canada, 18 percent; Mexico, 17 percent; and Australia, 14 percent. The European area continued supplying larger than usual exports to the United States. Belgium-Luxembourg, West Germany, United Kingdom, and Yugoslavia together contributed 24 percent of the total.

Reclaimed scrap imports declined as did imports of semiprocessed lead in sheets, pipe, and shot.

WORLD REVIEW

Statistical summaries of world production and consumption of lead compiled by the Bureau of Mines, American Bureau of Metal Statistics (ABMS), and the International Lead and Zinc Study Group vary in reporting base, reporting sources, and scope of estimating. The Bureau of Mines reports indicate the basis, insofar as possible, used for each country whereas the Study Group reports on an ore content basis. Therefore, free world mine production in 1968 ranged from the ABMS total of 2.39 million tons through the Bureau of Mines total of 2.44 million tons to the Lead and Zinc Study Group total of 2.48 million tons. In addition, the Bureau of Mines estimated production in the communist areas, other than Yugoslavia, to be 870,100 tons and the world total is thus 3.31 million tons in comparison to 3.17 million tons in 1967, an increase of 4.2 percent. Smelter output also varies widely with the Bureau of Mines reporting, insofar as possible, primary metal while the Lead and Zinc Study Group reports metal output from both primary and secondary sources. Free world smelter output in 1968 thus ranged from the 2.38 million tons reported by the Bureau of Mines through the ABMS total of 2.59 million tons, to the Lead and Zinc Study Group total of 3.18 million tons. An additional 858,000 tons of smelter output was estimated by the Bureau of Mines for the communist countries, other than Yugoslavia, to provide a 3.2-million-ton world primary smelter production.[14] The Lead and Zinc Study Group reports free world lead consumption on the same basis as smelter metal production and the statistics are thus comparative as to metal balance.

Major gains in mine production occurred in Canada, Mexico, and the United States to post an increase of 102,100 tons (13 percent), for the North American Continent. South American output was increased 9,300 tons, mainly in Bolivia and Peru. The European output remained essentially static with increases in France, Ireland, Spain, and Yugoslavia balanced by decreases in West Germany, Italy, and Sweden. Increased output was also indicated in Poland. A significant increase in output in Africa resulted from resumption of operations at some of the mines in Morocco and also improved results in Zambia. South Korea and Burma provided an increase in Asia of about 9,400 tons for the free world and North Korean and Chinese production was believed to have increased about 15,000 tons.

Smelter production in North America increased 159,000 tons, a 15-percent rise from the 1967 level. All countries posted an increase with the largest in the United States. South America was essentially the same as the prior year with the Peruvian increase balanced by a decline in Brazil.

---

[14] American Bureau of Metal Statistics. Yearbook. 1968, pp. 48–65.
International Lead and Zinc Study Group. Monthly Bulletin. June 1969, p. 10.

European primary production was indicated to be slightly lower than in 1967 with significant declines in West Germany, Belgium, and Italy more than offsetting the increased output in Spain and the United Kingdom. Communist output, including Yugoslavia, was also indicated to be slightly reduced. An increase in Zambia and Morocco was also more than countered by the decline in smelter output in the Territory of South-West Africa. Japan posted an increase of almost 10 percent in 1968 and has shown an annual growth of 14 percent since 1964. Australian production of refined lead decreased 17,600 tons due to shortage of concentrates from the labor-curtailed Broken Hill mines while bullion production from Mount Isa increased to a new high.

Consumption of metal in the free world in 1968 as reported by the Lead and Zinc Study Group preliminary totals was 3.23 million tons of which the United States accounted for 37 percent. Six countries—France, West Germany, Italy, United Kingdom, Japan, and the United States—used over 100,000 tons and together accounted for 69 percent of the total. Compared with the 3.18 million ton free world metal production reported by the Lead and Zinc Study Group, the supply deficit amounted to 50,000 tons in 1968 and was met by a 14,900-ton reduction in producers stocks, U.S. stockpile sales, and consumer stocks reduction.

Argentina.—Compañía Minera Aguilar, S.A., a subsidiary of St. Joseph Lead Co., milled approximately the same tonnage as in 1967 despite the operational problems of a mill expansion program, and produced for sale on the Argentine market 31,100 tons of lead concentrates.

Australia.—Production at Broken Hill mines was again affected by labor disturbances which resulted in a significantly lower production of lead concentrates and a decrease in refined lead production at the Port Pirie smelter.

Mount Isa Mines Ltd., 53 percent owned by American Smelting and Refining Company, increased lead production from 71,800 tons to 99,200 tons in the year ending June 30, 1968. The completion of crushing facilities and related ore passes for the new K–57 shaft during the year permitted use of the U–52 shaft exclusively for lead-zinc ore production. Installation of new equipment in the lead smelter was also completed.[15]

Canada.—Canadian production increased over 6 percent as Pine Point Mines Ltd. in British Columbia and Ecstall Mining, Ltd., in Ontario, a wholly owned subsidiary of Texas Gulf Sulphur Co., continued to expand output and Nigadoo River Mines Ltd., New Brunswick; Share Mines & Oils, Ltd., Saskatchewan; and Western Mines Ltd., British Columbia, completed this first full year's production.

Cominco Ltd., including its subsidiary Pine Point Mines Ltd., remained the dominant lead producer with an output of 199,300 tons in ore and production of 190,300 tons of refined lead at the Trail, British Columbia, smelter. The Sullivan and Bluebell mines contributed 41 percent of concentrates, 50 percent came from the Pine Point mine, 3 percent from other mines, and 6 percent from purchased slags and residues.

High-grade ore shipments from Pine Point accounted for 47 percent of the sales revenue in 1968 and were terminated in mid-December with exhaustion of presently available high-grade ore reserves. At yearend the orebody acquired from Pyramid Mining Co., Ltd., was ready for production and the addition to the Pine Point concentrator to treat this ore was completed and under full scale testing. Reserves at the Sullivan, Bluebell, and H. B. mines were estimated at 69 million tons containing 7.6 million tons of lead-zinc and reserves at the Pine Point mine estimated at 39.3 million tons containing 3.7 million tons of lead-zinc.[16]

Anvil Mining Corp., Ltd., continued stripping of overburden from the open pit lead-zinc mine in the Yukon with 50 percent of the preproduction stripping and construction of a 5,500-ton-per-day concentrator completed. Initial production is scheduled for late 1969 at an annual rate of 130,000 tons of 69-percent-lead concentrates. Reserves are estimated at 63 million tons averaging 9 percent lead-zinc.

The Kidd Creek mine of Ecstall Mining, Ltd. near Timmins, Ontario, increased ore production to 3.6 million tons and lead concentrate production to 96,000 tons.

---

[15] American Smelting and Refining Company. Annual Report. 1968, pp. 6–7.

[16] Cominco, Ltd. Annual Report. 1968, pp. 8–11.

Brunswick Mining and Smelting Corp., Ltd. milled 1.7 million tons from the No. 12 mine averaging 8.56 percent zinc and 3.38 percent lead with a production of 119,500 tons of lead concentrates. The No. 6 mine output was almost 1 million tons averaging 5.66 percent zinc and 2.47 percent lead, from which 46,330 tons of lead-zinc concentrate and 38,830 tons of lead concentrate were recovered. Reserves of ore at the two mines are estimated at 78.6 million tons. The East Coast Smelting and Chemical Co., Ltd., a subsidiary of Brunswick Mining and Smelting Corp., completed the first full year's operation of an Imperial Smelting Process plant at Belledune, New Brunswick.

Heath Steele Mines Ltd., 75 percent owned by American Metal Climax, Inc., increased ore production from its lead-zinc mine as a result of active mine development and shaft sinking program. The Buchans Unit of American Smelting and Refining Company in Newfoundland operated at capacity throughout the year and produced 38,400 tons of lead concentrates.

Germany, West.—Rammelsberg mine, Europe's oldest continuously operated lead, copper, and silver producer, celebrated its thousandth anniversary in 1968. Mining operations began in 968 under Emperor Otto I and have continued since under many ownerships. This mine along with neighboring mines on the northern edge of the Hartz Mountains belong to Sparte Metall, a subsidiary of Preussag A.G. of Hanover.

Iran.—Rio Tinto-Zinc Corp. Ltd. placed a 600-ton-per-day mill in operation late in 1968 at the Kouchke mine east of Yazd in central Iran. The project is owned by Rio Tinto, Société Minière et Métallurgigue de Peñarroya and the Iranian company Simiran. Annual production of 50,000 tons of mixed lead-zinc concentrate will be shipped to European smelters.

Four Belgian companies operating as Sogemiran S.p.A. produced lead and barite concentrates at a new 500-ton-per-day flotation mill near Dalijan. The lead concentrates were being exported for European smelting and the barite used locally in oil-well drilling.

Ireland.—The Irish Base Metals, Ltd. operations at Tynagh, Galway, the major lead-zinc development in 1966, was joined in early 1968 by a second large development, Consolidated Mogul Mines, Ltd., with a designed capacity of 3,000 tons per day. The reserves at this mine were estimated at 11.4 million tons averaging 8.16 percent zinc and 2.8 percent lead.

Japan.—A new Imperial Smelting Process furnace installation was nearing completion on Honshu Island. The smelter is owned by six Japanese metal companies.

Mexico.—Asarco Mexicana, S.A., 49 percent owned by American Smelting and Refining Company, produced slightly less lead than in 1967 although tonnage of ore mined increased. Continued progress was made in the mine and plant expansion program with completion of a 400-ton-per-day mill at the Plomosas mine and the new 600-ton-per-day mill at the San Marton mine along with expansion of the Santa Barbara mill to 2,000 tons per day expected to be completed in 1969. Ore reserves at the various operating mines were maintained during the year.

Poland.—A new lead-zinc mine in the Olkusz area near Krakon began operation in December at one of the world's richest deposits of lead and zinc according to Polish sources. Polish output of refined lead totaled 44,800 tons in 1967 and was scheduled to increase to 53,900 tons in 1968 and 57,400 tons in 1969.

TECHNOLOGY

Technological development continued to be a major activity in the lead industry and associated research organizations. Adaptation of large-capacity equipment and mining methods to underground mining in the Missouri mines have significantly increased manpower productivity. Automation of concentrating plants and smelters has also increased productivity, product uniformity, and byproduct recovery. Utilization of updraft sintering machines at lead smelters has resulted in increased sulfuric acid production and reduction in air pollution from stack gases.

Consumer service is perhaps the most vital area of development in the lead industry in view of the substitution potential of plastics and other materials. Automated soldering techniques have expanded greatly to step up production in assembly wiring. The lubricating quality of lead as a lead phosphate coating on steel has permitted significant increases in stamping press output. Development of a sintered ferrous skeleton impregnated with 15 to 30 percent lead for electric railroad power shoe has many potential applications in moving machine parts. Research and development of adhesives and lamination techniques for lead-plastic composites promise to combine the respective benefits of each material. Organolead chemicals have received major attention in the area of lubricants, catalysts, wood preservatives, and rot-resistant textiles.

Table 2.—Mine production of recoverable lead in the United States, by States

(Short tons)

State	1964	1965	1966	1967	1968
Alaska	---------	(1)	14	---------	(1)
Arizona	6,147	5,913	5,211	4,771	1,704
California	1,546	1,810	1,976	1,735	4,001
Colorado	20,563	22,495	23,082	21,923	19,778
Idaho	71,312	66,606	72,334	61,387	54,790
Illinois	2,180	3,005	2,285	2,384	1,467
Kansas	1,185	1,644	1,109	1,031	1,227
Kentucky	858	756	484	845	(1)
Missouri	120,148	133,521	132,255	152,649	212,611
Montana	4,538	6,981	4,409	898	1,870
Nevada	809	2,277	3,581	1,500	863
New Mexico	1,626	3,387	1,596	1,827	1,363
New York	732	601	1,097	1,653	1,396
Oklahoma	2,781	2,813	2,999	2,727	2,387
Oregon	(1)	(1)	---------	---------	(1)
Tennessee	---------	---------	181	---------	---------
Utah	40,249	37,700	64,124	53,813	45,205
Virginia	3,857	3,651	3,078	3,430	3,573
Washington	5,731	6,328	5,859	2,762	5,655
Wisconsin	1,742	1,645	1,694	1,596	1,126
Other States	6	14	---------	---------	140
Total	286,010	301,147	327,368	316,931	359,156

[1] Combined with "Other States" to avoid disclosing individual company confidential data.

Table 3.—Ore, old tailings, etc., yielding lead and zinc in the United States in 1968

(Short tons)

State	Lead ore			Zinc ore			Lead-zinc ore		
	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc
Arizona	498	45	(1)	194	1	14	98,566	1,635	3,448
California	6,112	1,629	245	12	1	1	63,297	2,229	3,274
Colorado	1,924	170	4	257,871	1,622	24,415	269,318	7,248	10,858
Idaho	160,949	13,211	1,506	44,845	1,203	3,326	666,670	33,398	44,536
Kansas	---	---	---	84,176	277	1,860	75,936	950	1,152
Missouri	6,355,777	212,589	12,260	---	---	---	475	22	41
Montana	5,514	970	108	14,551	169	1,302	952	74	45
Nevada	9,191	214	32	1,151	42	234	70,304	601	1,835
New Jersey	---	---	---	156,745	---	25,668	---	---	---
New Mexico	43	5	---	245,454	1,335	17,713	(2)	(2)	(2)
New York	---	---	---	785,109	1,396	66,194	---	---	---
Oklahoma	254	4	---	203,684	1,606	5,556	71,537	777	1,365
Pennsylvania	---	---	---	629,136	---	30,382	---	---	---
Tennessee	---	---	---	4,344,180	---	115,999	---	---	---
Utah	432	46	9	42	(1)	4	433,963	40,275	29,210
Virginia	---	---	---	659,207	3,573	19,257	---	---	---
Washington	---	---	---	364,837	701	9,237	197,886	4,954	4,647
Wisconsin	---	---	---	923,308	1,126	25,711	---	---	---
Other States	---	---	---	376,627	221	16,081	---	---	---
Total	6,540,694	228,883	14,164	9,091,129	13,273	362,954	1,948,904	92,163	100,406

State	Copper-lead, copper-zinc, and copper-lead-zinc ores			All other sources [3]			Total		
	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc	Gross weight	Lead	Zinc
Arizona	22,090	2	1,606	30,165,674	21	378	30,287,022	1,704	5,441
California	---	---	---	3,543	142	5	72,964	4,001	3,525
Colorado	450,697	10,374	14,872	74,919	364	109	1,054,729	19,778	50,258
Idaho	---	---	---	804,292	6,978	7,880	1,676,756	54,790	57,248
Kansas	---	---	---	---	---	---	160,112	1,227	3,012
Missouri	---	---	---	---	---	---	6,356,252	212,611	12,301
Montana	---	---	---	80,256	657	2,323	101,273	1,870	3,778
Nevada	---	---	---	8,589	6	3	89,235	863	2,104
New Jersey	---	---	---	---	---	---	156,745	---	25,668
New Mexico	[2] 65,299	[2] 12	[2] 743	578,895	11	230	889,691	1,363	18,686
New York	---	---	---	---	---	---	785,109	1,396	66,194
Oklahoma	---	---	---	---	---	---	275,475	2,387	6,921
Pennsylvania	---	---	---	---	---	---	629,136	---	30,382
Tennessee	1,624,400	---	8,040	---	---	---	5,968,580	---	124,039
Utah	122,381	4,682	3,526	8,559	202	404	565,377	45,205	33,153
Virginia	---	---	---	---	---	---	659,207	3,573	19,257
Washington	---	---	---	17	---	(1)	562,740	5,655	13,884
Wisconsin	---	---	---	---	---	---	923,308	1,126	25,711
Other States	---	---	---	511,249	1,386	11,803	887,876	1,607	27,884
Total	2,284,867	15,070	28,787	32,235,993	9,767	23,135	52,101,587	359,156	529,446

[1] Less than ½ unit.
[2] Lead-zinc and copper-lead, copper-zinc, and copper-lead-zinc ores combined to avoid disclosing individual company confidential data.
[3] Lead and zinc recovered from copper, gold, silver, fluorspar, and from smelter slags, mill trailings, and miscellaneous cleanups.

Table 4.—Mine production of recoverable lead in the United States, by months

(Short tons)

Month	1967	1968	Month	1967	1968
January	25,622	24,493	August	24,730	33,163
February	25,428	24,282	September	22,839	31,119
March	30,065	24,083	October	25,366	36,567
April	29,368	27,440	November	24,225	33,188
May	32,051	31,052	December	24,822	33,943
June	28,032	28,965			
July	24,383	30,861	Total	316,931	359,156

Table 5.—Twenty-five leading lead-producing mines in the United States in 1968, in order of output

Rank	Mine	County and State	Operator	Source of lead
1	Fletcher	Reynolds, Mo	St. Joseph Lead Co	Lead ore.
2	Viburnum	Crawford, Iron, and Washington, Mo.	do	Do.
3	Federal	St. Francois, Mo	do	Do.
4	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc ore, silver tailings, zinc ore.
5	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co.	Lead-zinc ore.
6	Magmont	Iron, Mo	Cominco American, Inc	Lead ore.
7	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
8	Indian Creek	Washington, Mo	St. Joseph Lead Co	Lead ore.
9	Burgin	Utah, Utah	Kennecott Copper Corp	Lead-zinc ore.
10	Lucky Friday	Shoshone, Idaho	Hecla Mining Co	Lead ore.
11	Ozark	Reynolds, Mo	Ozark Lead Co	Do.
12	Star-Morning	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
13	Pend Oreille	Pend Oreille, Wash	Pend Oreille Mines & Metals Co	Do.
14	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
15	United Park City	Summit, Utah	United Park City Mines Co	Lead-zinc ore.
16	Page	Shoshone, Idaho	American Smelting and Refining Company.	Do.
17	Austinville and Ivanhoe	Wythe, Va	The New Jersey Zinc Co	Do.
18	Ophir	Tooele, Utah	United States Smelting Refining and Mining Co.	Do.
19	Darwin	Inyo, Calif	West Hill Exploration Co	Do.
20	Dayrock	Shoshone, Idaho	Day Mines, Inc	Lead ore.
21	Iron King	Yavapai, Ariz	McFarland and Hullinger	Lead-zinc ore.
22	Eagle	Eagle, Colo	The New Jersey Zinc Co	Zinc, silver ores.
23	Brenneman	San Juan, Colo	Standard Metals Corp	Lead-zinc ore.
24	Sunnyside	do	do	Do.
25	Emperius	Mineral, Colo	Emperius Mining Co	Do.

Table 6.—Refined lead produced at primary refineries in the United States, by source material

(Short tons)

	1964	1965	1966	1967	1968
Refined lead:					
From primary sources:					
Domestic ores and base bullion	294,254	305,007	318,646	258,507	349,039
Foreign ores and base bullion	155,175	113,242	122,089	121,387	118,271
Total	449,429	418,249	440,735	379,894	467,310
From secondary sources	8,505	13,140	9,004	2,538	2,259
Grand total	457,934	431,389	449,739	382,432	469,569
Calculated value of primary refined lead (thousands)[1]	$122,424	$133,840	$133,278	$106,370	$123,463

[1] Value based on average quoted price, New York, and excludes value of refined lead produced from scrap at primary refineries.

Table 7.—Antimonial lead produced at primary lead refineries in the United States

Year	Production (short tons)	Antimony content		Lead content by difference (short tons)			
		Short tons	Percent	From domestic ore	From foreign ore	From scrap	Total
1964	24,023	1,995	8.3	4,522	4,085	13,421	22,028
1965	27,895	1,984	7.1	2,809	3,803	19,299	25,911
1966	24,059	2,119	8.8	6,025	5,157	10,758	21,940
1967	18,608	1,717	9.2	5,449	3,634	7,808	16,891
1968	28,363	2,007	7.1	15,788	3,706	6,862	26,356

Table 8.—Stocks and consumption of new and old lead scrap in the United States in 1968

(Short tons, gross weight)

Class of consumers and type of scrap	Stocks Jan. 1 [r]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and refiners:						
Soft lead	2,600	51,691	-------	52,611	52,611	1,680
Hard lead	1,446	14,648	-------	14,732	14,732	1,362
Cable lead	943	31,774	-------	31,926	31,926	791
Battery-lead plates	28,735	461,644	-------	464,046	464,046	26,333
Mixed common babbitt	335	4,071	-------	4,080	4,080	326
Solder and tinny lead	279	11,352	-------	11,405	11,405	226
Type metals	3,603	34,865	-------	35,049	35,049	3,419
Drosses and residues	19,767	107,577	103,968	-------	103,968	23,376
Total	57,708	717,622	103,968	613,849	717,817	57,513
Foundries and other manufacturers:						
Soft lead	16	121	-------	135	135	2
Hard lead	24	119	-------	99	99	44
Cable lead	18	50	-------	20	20	48
Battery-lead plates	47	26	-------	-------	-------	73
Mixed common babbitt	82	7,581	-------	7,583	7,583	80
Solder and tinny lead	------	-------	-------	-------	-------	------
Type metals	------	-------	-------	-------	-------	------
Drosses and residues	84	-------	-------	-------	-------	84
Total	271	7,897	-------	7,837	7,837	331
All consumers:						
Soft lead	2,616	51,812	-------	52,746	52,746	1,682
Hard lead	1,470	14,767	-------	14,831	14,831	1,406
Cable lead	961	31,824	-------	31,946	31,946	839
Battery-lead plates	28,782	461,670	-------	464,046	464,046	26,406
Mixed common babbitt	417	11,652	-------	11,663	11,663	406
Solder and tinny lead	279	11,352	-------	11,405	11,405	226
Type metals	3,603	34,865	-------	35,049	35,049	3,419
Drosses and residues	19,851	107,577	103,968	-------	103,968	23,460
Grand total	57,979	725,519	103,968	621,686	725,654	57,844

[r] Revised.

Table 9.—Secondary metal recovered[1] from lead and tin scrap in the United States in 1968, by type of products

(Short tons, gross weight)

	Lead	Tin	Antimony	Other	Total
Refined pig lead	118,015	---------	---------	-----	118,015
Remelt lead	20,851	---------	---------	-----	20,851
Total	138,866	---------	---------	-----	138,866
Refined pig tin	-------	3,153	---------	-----	3,153
Remelt tin	-------	182	---------	-----	182
Total	-------	3,335	---------	-----	3,335
Lead and tin alloys:					
Antimonial lead	308,563	448	17,365	329	326,705
Common babbitt	12,196	709	1,452	60	14,417
Genuine babbitt	35	229	25	10	299
Solder	29,637	4,721	503	90	34,951
Type metals	27,334	1,797	4,163	18	33,312
Cable lead	17,884	---------	174	5	18,063
Miscellaneous alloys	1,222	349	17	109	1,697
Total	396,871	8,253	23,699	621	429,444
Tin content of chemical products	-------	587	---------	-----	587
Grand total	535,737	12,175	23,699	621	572,232

[1] Most of the figures herein represent actual reported recovery of metal from scrap.

Table 10.—Secondary lead recovered in the United States

(Short tons)

	1964	1965	1966	1967	1968
As metal:					
At primary plants	8,505	13,140	9,004	2,538	2,259
At other plants	140,702	168,774	147,215	147,806	136,607
Total	149,207	181,914	156,219	150,344	138,866
In antimonial lead:					
At primary plants	13,421	19,299	10,758	7,808	6,862
At other plants	257,101	251,354	272,977	280,911	301,701
Total	270,522	270,653	283,735	288,719	308,563
In other alloys	121,853	123,252	132,880	114,709	103,450
Grand total:					
Quantity	541,582	575,819	572,834	553,772	550,879
Value (thousands)[1]	$147,527	$184,262	$173,225	$155,056	$145,542

[1] Value based on average quoted price, New York.

Table 11.—Lead recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1967	1968	Form of recovery	1967	1968
New scrap:			As soft lead:		
Lead-base	71,829	73,845	At primary plants	2,538	2,259
Copper-base	4,500	5,219	At other plants	147,806	136,607
Tin-base	578	548			
Total	76,907	79,612	Total	150,344	138,866
			In antimonial lead [1]	288,719	308,563
Old scrap:			In other lead alloys	96,884	87,273
Battery-lead plates	303,258	310,215	In copper-base alloys	17,795	16,142
All other lead-base	155,892	142,963	In tin-base alloys	30	35
Copper-base	17,711	18,085			
Tin-base	4	4	Total	403,428	412,013
Total	476,865	471,267	Grand total	553,772	550,879
Grand total	553,772	550,879			

[1] Includes 7,808 tons of lead recovered in antimonial lead from secondary sources at primary plants in 1967 and 6,862 tons in 1968.

Table 12.—Lead consumption in the United States, by products

(Short tons)

Product	1967	1968	Product	1967	1968
Metal products:					
Ammunition	78,766	82,193	Pigments—Continued		
Bearing metals	19,561	18,441	Pigment colors	13,041	14,163
Brass and bronze	20,467	21,021	Other [1]	5,473	3,234
Cable covering	63,037	53,456			
Calking lead	48,789	49,718	Total	103,190	109,734
Casting metals	10,083	8,693			
Collapsible tubes	11,299	9,310	Chemicals:		
Foil	6,148	6,114	Gasoline antiknock additives	247,170	261,897
Pipes, traps, and bends	20,184	21,098			
Sheet lead	26,763	28,271	Miscellaneous chemicals	609	629
Solder	68,833	74,074			
Storage batteries:			Total	247,779	262,526
Battery grids, posts, etc	229,287	250,129	Miscellaneous uses:		
Battery oxides	237,378	263,574	Annealing	4,202	4,194
Terne metal	1,620	1,427	Galvanizing	1,854	1,755
Type metal	28,554	27,981	Lead plating	532	389
			Weights and ballast	15,794	16,768
Total	870,769	915,500	Total	22,382	23,106
Pigments:			Other, unclassified uses	16,396	17,924
White lead	8,087	5,857			
Read lead and litharge	76,589	86,480	Grand total [2]	1,260,516	1,328,790

[1] Includes lead content of leaded zinc oxide and other pigments.
[2] Includes lead which went directly from scrap to fabricated products.

Table 13.—Lead consumption in the United States, by months

(Short tons)

Month	1967	1968	Month	1967	1968
January	107,431	110,608	August	104,406	110,908
February	99,789	106,261	September	102,553	114,312
March	112,912	106,621	October	111,920	133,133
April	106,964	108,113	November	107,967	116,574
May	110,808	112,139	December	105,594	112,341
June	106,011	104,479			
July	84,161	93,301	Total [1]	1,260,516	1,328,790

[1] Includes lead content of leaded zinc oxide and other pigments and lead which went directly from scrap to fabricated products.

Table 14.—Lead consumption in the United States in 1968, by class of products and types of material

(Short tons)

Product	Soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
Metal products	194,833	104,773	48,974	15,670	364,250
Storage batteries	270,205	243,498	---------	---------	513,703
Pigments	107,258	---------	---------	---------	107,258
Chemicals	262,354	172	---------	---------	262,526
Miscellaneous	10,252	12,814	40	---------	23,106
Unclassified	15,381	2,079	464	---------	17,924
Total	860,283	363,336	49,478	15,670	[1] 1,288,767

[1] Excludes 37,547 tons of lead which went directly from scrap to fabricated products and 2,476 tons of lead contained in leaded zinc oxide and other nonspecified pigments.

Table 15.—Lead consumption in the United States in 1968, by States[1]

(Short tons)

State	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
California	89,212	31,622	6,241	709	127,784
Colorado	1,114	2,500	95	---------	3,709
Connecticut	17,171	16,442	112	1,520	35,245
District of Columbia	150	---------	---------	---------	150
Florida	6,249	5,283	---------	---------	11,532
Georgia	39,720	16,199	2,517	---------	58,436
Illinois	80,816	50,272	9,846	2,093	143,027
Indiana	76,831	42,411	1,585	814	121,641
Kansas	11,046	9,151	38	377	20,612
Kentucky	2,795	7,115	1	---------	9,911
Maryland	4,374	17,414	166	---------	21,954
Massachusetts	4,147	866	193	47	5,253
Michigan	18,158	20,879	1,881	433	41,351
Missouri	38,042	14,684	164	420	53,310
Nebraska	2,805	1,016	26	778	4,625
New Jersey	127,942	21,498	9,055	489	158,984
New York	40,120	2,280	9,552	780	52,732
Ohio	13,988	3,928	3,432	836	22,184
Pennsylvania	51,449	31,448	1,120	3,044	87,061
Rhode Island	1,276	450	35	---------	1,761
Tennessee	170	11,337	328	252	12,087
Virginia	1,211	1,193	738	1,337	4,479
Washington	6,663	478	314	---------	7,455
West Virginia	18,963	3,043	---------	---------	22,006
Wisconsin	3,065	2,807	42	148	6,062
Alabama and Mississippi	1,003	2,865	---------	623	4,491
Arkansas and Oklahoma	3,631	3,386	99	---------	7,116
Hawaii and Oregon	940	2,672	---------	---------	3,612
Iowa and Minnesota	3,131	8,615	127	490	12,363
Louisiana and Texas	182,253	21,133	1,726	312	205,424
Montana and Idaho	4,691	---------	---------	---------	4,691
New Hampshire, Maine, Vermont, Delaware	5,067	7,711	45	168	12,991
North and South Carolina	2,001	2,638	---------	---------	4,639
Utah, Nevada, Arizona	89	---------	---------	---------	89
Total	860,283	363,336	49,478	15,670	1,288,767

[1] Excludes 37,547 tons of lead which went directly from scrap to fabricated products and 2,476 tons of lead contained in leaded zinc oxide and other non-specified pigments.

Table 16.—Production and shipments of leaded pigments[1] and oxides in the United States

Pigment	1967				1968			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value[2]			Short tons	Value[2]	
			Total	Average per ton			Total	Average per ton
White lead:								
Dry	7,316	8,871	$3,609,808	$407	6,614	8,578	$3,514,502	$410
In oil[3]	2,807	3,257	2,205,973	677	2,822	3,056	2,087,601	683
Total	10,123	12,128	5,815,781	480	9,436	11,634	5,602,103	482
Red lead	26,869	25,741	8,814,995	342	23,816	23,811	8,458,714	355
Litharge	95,581	99,982	32,135,289	321	114,900	131,178	38,721,968	295
Black oxide	203,571	-------	----------	----	218,119	-------	----------	----

[1] Except for basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.
[2] At plant, exclusive of container.
[3] Weight of white lead only, but value of paste.

Table 17.—Lead content of lead and zinc pigments[1] and lead oxides produced by domestic manufacturers, by sources

(Short tons)

Pigment	1967				1968			
	Lead in pigments produced from—			Total lead in pigments	Lead in pigments produced from—			Total lead in pigments
	Ore		Pig lead		Ore		Pig lead	
	Domestic	Foreign			Domestic	Foreign		
White lead	---------	---------	8,098	8,098	-----	-----	7,549	7,549
Red lead	---------	---------	24,357	24,357	-----	-----	21,589	21,589
Litharge	---------	---------	88,890	88,890	-----	-----	106,857	106,857
Black oxide	---------	---------	194,909	194,909	-----	-----	208,067	208,067
Leaded zinc oxide	798	512	---------	1,310	768	706	---------	1,474
Total	798	512	316,254	317,564	768	706	344,062	345,536

[1] Excludes lead in basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.

Table 18.—Distribution of white lead (dry and in oil) shipments,[1] by industries

(Short tons)

Industry	1964	1965	1966	1967	1968
Paints	10,534	9,185	8,260	6,968	6,681
Ceramics	143	133	130	96	124
Other	4,769	5,355	6,486	5,064	4,829
Total	15,446	14,673	14,876	12,128	11,634

[1] Excludes basic lead sulfate, figures withheld to avoid disclosing individual company confidential data.

Table 19.—Distribution of red lead shipments, by industries

(Short tons)

Industry	1964	1965	1966	1967	1968
Paints	14,133	13,725	14,480	13,318	11,347
Other	13,957	15,938	16,790	12,423	12,464
Total	28,090	29,663	31,270	25,741	23,811

Table 20.—Distribution of litharge shipments, by industries

(Short tons)

Industry	1964	1965	1966	1967	1968
Ceramics	20,508	21,013	23,476	19,491	24,123
Chrome pigments	6,426	W	W	W	W
Insecticides	W	1,161	1,166	W	W
Oil refining	2,142	2,886	1,991	1,835	1,849
Rubber	1,978	2,153	2,296	1,928	1,986
Varnish	4,004	3,763	1,620	1,228	W
Other	64,335	74,916	79,754	75,500	103,220
Total	99,393	105,892	110,303	99,982	131,178

W Withheld to avoid disclosing individual company confidential data; included with "Other."

Table 21.—U.S. imports for consumption of lead pigments and compounds

Kind	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
White lead	2,293	$672	2,158	$672
Red lead	3,296	761	4,412	977
Litharge	24,632	4,969	24,829	5,131
Other lead pigments	[r] 76	22	207	54
Other lead compounds	[r] 372	[r] 152	398	116
Total	[r] 30,669	[r] 6,576	32,004	6,950

[r] Revised.

Table 22.—Stocks of lead at primary smelters and refineries in the United States, December 31

(Short tons)

Stocks	1964	1965	1966	1967	1968
Refined pig lead	34,100	17,524	16,175	18,243	11,490
Lead in antimonial lead	4,012	7,680	6,396	5,119	3,852
Lead in base bullion	13,218	10,735	15,606	16,622	11,471
Lead in ore and matte	33,068	47,504	77,296	85,495	63,614
Total	84,398	83,443	115,473	125,479	90,427

Table 23.—Consumer stocks of lead in the United States, December 31, by types of material

(Short tons, lead content)

Year	Refined soft lead	Lead in antimonial lead	Lead in alloys	Lead in copper-base scrap	Total
1964	69,361	35,163	7,933	987	113,444
1965	61,586	36,190	10,406	1,013	109,195
1966	44,490	34,704	10,071	1,041	90,306
1967	59,837	35,879	8,919	1,151	105,786
1968	43,933	35,009	9,184	774	88,900

Table 24.—Average monthly and yearly quoted prices of lead at St. Louis, New York, and London[1]

(Cents per pound)

Month	1967			1968		
	St. Louis	New York	London[2]	St. Louis	New York	London[2]
January	13.80	14.00	9.96	13.80	14.00	9.98
February	13.80	14.00	10.04	13.80	14.00	10.36
March	13.80	14.00	10.34	13.80	14.00	10.61
April	13.80	14.00	10.28	13.80	14.00	10.66
May	13.80	14.00	10.35	12.84	13.04	10.72
June	13.80	14.00	10.31	12.80	13.00	10.74
July	13.80	14.00	10.44	12.50	12.70	11.15
August	13.80	14.00	10.51	12.30	12.50	11.29
September	13.80	14.00	10.23	12.30	12.50	11.34
October	13.80	14.00	10.18	12.61	12.81	11.18
November	13.80	14.00	10.44	12.80	13.00	11.19
December	13.80	14.00	10.12	12.80	13.00	11.27
Average	13.80	14.00	10.28	13.01	13.21	10.88

[1] St. Louis: Metal Statistics, 1969. New York: Metal Statistics, 1969. London: Metals Week.
[2] Based on monthly rates of exchange by Federal Reserve Board.

Table 25.—U.S. exports of lead, by countries[1]

Destination	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
PIGS, BARS AND ANODES						
Belgium-Luxembourg	1,115	$913	13	$22	769	$799
Brazil	799	250	558	163	504	166
Canada	299	309	353	360	450	372
Chile	56	27	587	205	1,404	521
Colombia	530	237	237	71	37	20
Italy	12	23	42	51	664	266
Japan	15	18	1,402	491	1,145	285
Mexico	156	98	200	550	141	90
Netherlands	118	364	156	405	412	343
Philippines	68	41	119	89	287	119
Spain	11	8	1	3	59	36
Sweden	151	120	263	472	187	137
Taiwan	233	88	190	60	31	18
United Kingdom	200	348	321	471	191	284
Venezuela	346	214	206	208	634	222
Vietnam, South	521	227	19	6	99	34
Other	805	682	1,869	1,140	1,267	1,028
Total	5,435	3,967	6,536	4,767	8,281	4,740
SCRAP						
Belgium-Luxembourg	101	20	35	15	207	50
Canada	-------	-------	56	34	116	24
Germany, West	-------	-------	-------	-------	113	17
Japan	-------	-------	16	10	-------	-------
Netherlands	238	68	139	55	124	28
United Kingdom	138	60	120	76	367	95
Other	21	17	28	8	10	5
Total	498	165	394	198	937	219
Grand total	5,933	4,132	6,930	4,965	9,218	4,959

[1] In addition foreign lead was reexported as follows: pigs, bars and anodes; 1966: 7 tons ($3,806), 1967: 162 tons ($33,794); 1968: 11 tons ($19,211). Scrap; 1966–68, none.

Table 26.—U.S. imports[1] of lead by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ore, flue dust, and matte (lead content):						
Australia	22,614	$4,963	25,553	$4,708	20,592	$3,772
Bolivia	11,136	2,433	13,764	2,680	5,718	994
Canada	52,707	12,018	33,474	6,928	36,815	6,733
Chile	7	1	159	33	490	89
Colombia	445	51	561	49	1	(2)
Guatemala	35	6	197	33	-------	-------
Honduras	11,132	2,347	6,513	1,367	9,272	1,782
Mexico	624	89	314	38	303	40
Peru	41,610	8,515	36,734	6,963	13,976	2,610
Philippines	164	44	37	11	1	1
South Africa, Republic of	1,394	460	359	32	608	97
Other	2,123	320	6,402	1,108	60	12
Total	143,991	31,247	124,067	23,950	87,836	16,130
Base bullion (lead content):						
Australia	1,283	326	-------	-------	-------	-------
Belgium-Luxembourg	-------	-------	442	118	-------	-------
Canada	62	27	23	96	14	78
France	-------	-------	55	12	-------	-------
Germany, West	56	14	-------	-------	-------	-------
Mexico	547	127	95	1,489	101	1,545
Peru	64	102	66	809	35	440
United Kingdom	-------	-------	71	16	-------	-------
Total	2,012	596	752	2,540	150	2,063
Pigs and bars (lead content):						
Australia	44,187	10,868	53,156	11,900	46,919	9,851
Belgium-Luxembourg	2,585	606	23,281	5,074	18,649	4,343
Burma	5,532	1,375	2,548	590	-------	-------
Canada	34,283	9,358	37,238	9,728	60,161	14,637
Denmark	672	184	423	226	46	41
Germany, West	15,499	6,002	49,077	12,726	20,711	7,552
Mexico	75,294	16,645	57,271	13,019	56,516	12,062
Peru	51,593	14,824	70,377	18,506	75,105	18,896
South Africa, Republic of	11,986	3,341	6,989	1,937	8,298	2,201
Sweden	-------	-------	3,308	728	3,868	847
United Kingdom	3,101	977	17,680	4,344	22,919	5,546
Yugoslavia	31,322	8,190	30,478	6,941	19,775	4,155
Zambia	1,148	318	-------	-------	-------	-------
Other	8,237	2,530	11,772	2,978	5,153	1,341
Total	285,389	75,218	363,598	88,697	338,120	81,472
Reclaimed scrap, etc. (lead content):						
Australia	[r]3,843	1,696	1,086	485	2,280	986
Canada	[r]2,857	696	6,431	1,319	2,834	528
Dominican Republic	179	28	248	42	292	31
Germany, West	-------	-------	1,472	333	-------	-------
Mexico	314	40	278	43	670	111
Netherlands Antilles	188	33	187	38	60	11
New Zealand	50	8	77	11	64	11
Panama	80	12	374	56	221	27
Other	[r]185	52	136	31	60	10
Total	[r]7,696	2,565	10,289	2,358	6,481	1,715
Grand total	[r]439,088	109,626	498,706	117,545	432,587	101,380

[r] Revised.

[1] Data are "general imports"; that is they include lead imported for immediate consumption plus material entering the country under bond.

[2] Less than ½ unit.

Table 27.—U.S. imports for consumption[1] of lead, by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ore, flue dust, and matte (lead content):						
Australia	21,460	$4,636	37,879	$7,160	12,640	$2,274
Bolivia	1,454	376	14,707	3,020	6,708	1,308
Canada	23,617	5,099	41,416	8,956	31,453	6,453
Chile	-------	-------	-------	-------	2,440	513
Colombia	228	34	892	172	113	17
Honduras	3,506	785	5,350	1,085	7,730	1,532
Ireland	-------	-------	-------	-------	5,459	1,130
Mexico	425	72	409	50	321	54
Peru	10,177	2,053	40,321	8,213	28,999	5,545
Philippines	-------	-------	264	73	1	1
South Africa, Republic of	2,963	811	478	51	836	133
Sweden	-------	-------	2,377	316	-------	-------
Other	20	5	63	15	163	30
Total	63,850	13,871	144,156	29,111	96,863	18,990
Base bullion (lead content):						
Australia	1,272	323	-------	-------	-------	-------
Belgium-Luxembourg	-------	-------	442	118	-------	-------
Canada	62	27	23	96	14	78
Germany, West	56	14	-------	-------	-------	-------
Mexico	474	109	20	173	13	125
Peru	64	102	66	809	36	440
United Kingdom	-------	-------	71	16	-------	-------
Other	-------	-------	55	12	-------	-------
Total	1,928	575	677	1,224	63	643
Pigs and bars (lead content):						
Australia	44,160	10,859	53,156	11,900	46,919	9,851
Belgium-Luxembourg	2,535	606	23,281	5,074	19,149	4,354
Burma	5,532	1,375	2,548	590	-------	-------
Canada	34,283	9,358	37,236	9,728	60,161	14,637
Denmark	672	184	423	226	46	41
Germany, West	15,499	6,002	49,077	12,726	19,711	7,333
Japan	2,106	522	-------	-------	-------	-------
Mexico	75,394	16,665	57,271	13,019	56,516	12,062
Morocco	-------	-------	2,413	485	-------	-------
Netherlands	5,137	1,518	878	313	205	65
Peru	51,593	14,824	70,377	18,506	75,105	18,896
South Africa, Republic of	11,925	3,324	6,989	1,937	8,298	2,201
United Kingdom	3,101	977	17,680	4,344	22,919	5,546
Yugoslavia	31,822	8,190	30,478	6,941	19,775	4,155
Other	2,529	908	11,789	2,908	8,816	2,123
Total	285,788	75,312	363,596	88,697	337,620	81,264
Reclaimed scrap, etc. (lead content):						
Australia	61	11	67	11	30	14
Canada	2,807	681	6,340	1,296	2,834	528
Dominican Republic	179	28	248	42	292	31
Germany, West	-------	-------	1,568	369	-------	-------
Japan	-------	-------	13	6	-------	-------
Mexico	314	40	278	43	670	111
Netherlands Antilles	188	33	167	35	60	11
New Zealand	50	8	80	12	64	11
Panama	80	12	374	56	221	27
Peru	150	46	-------	-------	-------	-------
Other	127	27	233	81	78	15
Total	3,956	886	9,368	1,951	4,249	748
Sheets, pipe and shot:						
Belgium-Luxembourg	219	64	513	129	344	90
Canada	30	13	99	38	182	66
Germany, West	134	45	2	(2)	12	4
Netherlands	514	154	402	105	243	64
United Kingdom	-------	-------	76	22	112	32
Other	22	7	120	28	-------	-------
Total	919	283	1,212	322	893	256
Grand total	356,441	90,927	519,009	121,305	439,688	101,901

[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.

[2] Less than ½ unit.

Table 28.—U.S. imports for consumption of lead, by classes[1]

(Thousand short tons and thousand dollars)

Year	Lead in ore, flue dust or fume, and matte, n.s.p.f. (lead content)		Lead in base bullion (lead content)		Pigs and bars (lead content)		Reclaimed scrap, etc. (lead content)		Sheets, pipe, and shot		Not otherwise specified (value)	Total value
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value		
1966	64	$13,871	2	$575	285	$75,312	4	$886	1	$283	$563	$91,490
1967	144	29,111	1	1,224	364	88,697	9	1,951	1	322	542	121,847
1968	97	18,990	(2)	643	338	81,264	4	748	1	256	273	102,174

[1] Excludes imports for consumption in bond and export, classified as "imports for consumption" by the Bureau of the Census.
[2] Less than ½ unit.

Table 29.—U.S. imports for consumption of miscellaneous products containing lead

Year	Babbitt metal, solder, white metal, and other combinations containing lead		
	Gross weight (short tons)	Lead content (short tons)	Value (thousands)
1966	1,589	731	$3,203
1967	775	413	1,423
1968	1,204	566	2,244

Table 30.—World mine production of lead (content of ore) by countries

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada	206,358	302,950	323,175	339,701	361,128
Guatemala [1]	[r] 1,330	[r] 1,017	[r] 993	1,279	520
Honduras	8,250	10,642	12,207	12,879	14,523
Mexico	[r] 187,345	[r] 183,843	[r] 192,072	188,500	191,988
United States [1]	286,010	301,147	327,368	316,931	359,156
South America:					
Argentina	28,576	35,534	34,884	32,253	34,022
Bolivia	18,180	17,981	21,484	21,755	24,609
Brazil	[e] 16,200	[e] 25,000	[r] 24,953	25,818	23,352
Chile	1,230	863	912	445	1,091
Colombia	534	507	658	665	816
Ecuador	183	126	76	NA	NA
Peru [1]	166,089	170,135	159,570	174,378	184,960
Europe:					
Austria [1]	5,727	5,553	5,336	5,295	6,400
Bulgaria	100,641	[e] 110,200	[e] 110,200	[e] 112,000	[e] 117,000
Czechoslovakia [e]	[r] 14,900	[r] 15,400	[r] 15,400	15,400	15,400
Finland	2,083	6,952	5,107	5,276	4,987
France	13,437	19,898	29,491	30,155	29,100
Germany:					
East [e]	11,000	11,000	13,000	12,000	13,000
West	53,944	54,727	61,099	65,535	57,867
Greece	8,962	10,626	10,748	[e] 9,900	[e] 9,900
Hungary	1,323	1,543	[e] 1,540	NA	NA
Ireland	1,323	2,853	44,100	66,000	68,000
Italy	[r] 35,632	39,098	40,456	42,626	40,207
Norway	3,945	3,860	3,887	3,660	[e] 4,030
Poland	42,200	45,400	49,700	49,300	53,700
Portugal	216	168	1,890	1,653	1,457
Rumania [e] [2]	14,000	17,000	44,000	44,000	44,000
Spain	64,356	62,435	[r] 69,923	69,030	78,594
Sweden	74,373	76,004	[r] 78,138	81,130	78,400
U.S.S.R. [e]	364,000	386,000	413,000	440,000	440,000
United Kingdom	198	101	--------	--------	--------
Yugoslavia	124,677	117,122	113,097	119,365	[e] 121,000
Africa:					
Algeria	10,525	11,514	[r] 4,398	3,586	3,770
Congo (Brazzaville)	2,391	[e] 3,100	3,900	NA	NA
Congo (Kinshasa)	1,152	1,709	1,168	[e] 1,100	--------
Morocco	78,584	85,000	85,536	57,707	79,787
Nigeria	--------	[e] 770	[e] 1,800	[e] 900	--------
South Africa, Republic of	--------	53	20	26	--------
South-West Africa,[1] Territory of	104,023	96,789	93,745	[e] 77,160	[e] 66,000
Tunisia	13,944	17,494	17,561	13,720	[e] 14,000
Zambia [2]	14,508	23,529	20,679	21,055	26,594
Asia:					
Burma	20,700	21,400	[r] 13,200	8,800	12,000
China, mainland [e]	110,000	110,000	110,000	100,000	110,000
India	4,966	4,388	4,116	2,608	2,810
Iran [3]	[r] 11,729	[r] 12,875	[r] 16,182	16,300	[e] 16,500
Japan	[r] 59,604	60,550	69,551	69,970	69,266
Korea:					
North [e]	60,000	66,000	66,000	72,000	77,000
South	[r] 4,059	[r] 5,367	[r] 8,422	10,675	19,031
Philippines	114	116	101	105	93
Thailand	4,030	6,152	7,028	3,833	3,000
Turkey	1,792	1,854	1,030	2,599	2,443
Oceania: Australia	419,839	405,594	[r] 408,687	420,035	427,556
Total [4]	[r] 2,779,182	[r] 2,969,939	[r] 3,141,583	3,169,108	3,309,057

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.
[1] Recoverable.
[2] Smelter production.
[3] Year ended March 21 of year following that stated.
[4] Total is of listed figures only.

Table 31.—World smelter production of lead by countries[1]

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada (refined)	151,372	186,484	184,871	190,279	202,100
Guatemala	83	126	237	78	220
Mexico	183,758	181,117	189,757	178,232	189,884
United States (refined)[2]	449,429	418,249	440,726	379,894	467,310
South America:					
Argentina	25,400	35,300	24,300	NA	NA
Bolivia (refined metal and solder)	508	1,032	1,246	261	NA
Brazil	14,417	10,654	10,955	18,997	17,821
Peru	98,904	95,668	97,843	90,185	91,900
Europe:					
Austria	9,365	8,481	7,907	8,586	7,779
Belgium [3]	91,840	122,089	102,139	107,696	105,300
Bulgaria [3]	96,451	102,979	[r] 102,346	[e] 106,500	107,000
Czechoslovakia [e] [3]	[r] 16,500	[r] 22,000	[r] 22,000	22,000	22,000
France	98,976	108,419	119,753	125,674	110,000
Germany:					
East [e] [3]	27,600	27,600	27,600	27,600	27,600
West	118,502	114,674	120,841	150,250	132,300
Greece (base bullion from ores)	5,500	5,700	6,060	6,060	9,768
Hungary	220	220	[e] 220	NA	NA
Italy	[r] 47,058	50,067	59,269	66,689	63,442
Poland [3]	45,747	45,620	47,936	48,832	46,300
Portugal (refined)[3]	1,506	1,442	[r] 1,166	1,183	1,358
Rumania [e]	14,000	17,000	44,000	44,000	44,000
Spain	63,927	59,321	[r] 72,643	57,937	70,188
Sweden (refined)	44,482	44,346	48,171	46,400	46,300
U.S.S.R.[e]	364,000	386,000	413,000	441,000	441,000
United Kingdom [4]	[r] 27,358	[r] 25,305	[r] 17,796	29,566	35,150
Yugoslavia [3]	111,427	[r] 111,889	[r] 107,809	103,452	104,540
Africa:					
Morocco	20,766	18,995	20,696	23,544	26,638
South-West Africa, Territory of	52,685	72,791	82,976	[e] 80,500	[e] 68,300
Tunisia [5]	13,331	15,627	15,403	14,600	--------
Zambia	14,508	23,529	20,679	21,055	26,594
Asia:					
Burma	19,900	[e] 17,600	[e] 15,400	[e] 14,300	9,300
China, mainland [e]	110,000	110,000	110,000	99,000	110,000
India	3,995	[r] 2,628	[r] 2,803	2,727	1,509
Iran [6]	413	[r] 367	[r] 387	[e] 390	[e] 390
Japan	106,962	119,433	130,715	165,316	181,410
Korea:					
North [e]	50,000	55,000	55,000	60,000	60,000
South	[e] 40	[e] 900	1,772	3,293	3,438
Turkey	2,161	1,012	550	[e] 550	[e] 550
Oceania: Australia:					
Refined lead	227,473	216,504	216,304	213,881	196,260
Lead bullion (for export)	87,701	74,936	83,210	107,046	193,328
Total [7]	[r] 2,818,265	[r] 2,911,104	[r] 3,026,486	3,057,553	3,220,977

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Primary, except as noted or source does not differentiate.

[2] Lead refined from domestic and foreign ores; excludes lead refined from imported base bullion.

[3] Includes recovery from secondary materials.

[4] Lead bullion from imported ores and concentrates.

[5] Lead bars only; does not include lead contained in antimonial lead or solder.

[6] Year ended March 21 of year following that stated.

[7] Total is of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/65

Lime

By Paul L. Allsman [1]

Paced by the expansion in basic-oxygen-furnace (BOF) steel flux use, sales of quicklime were up 8 percent. Total sales of open-market and captive lime increased 4 percent, while sales of hydrated lime decreased 11 percent, and production of dead-burned dolomite decreased 3 percent. Use of all types of captive lime increased 1 percent.

DOMESTIC PRODUCTION

The steel industry announced plans for two new fluxing lime plants during the year. Black River Mining Co., owned by Armco Steel Corp., Southwestern Portland Cement Co., and Marble Cliff Quarries, began construction of burnt lime producing facilities at Carntown, Ky., to serve BOF steelmaking plants at Ashland and Middletown, Ky. United States Steel Corp. reported plans for two new vertical kilns, adding 1,300 tons per day capacity of fluxing lime for BOF steel manufacture, at Lorraine, Ohio.

Bethlehem Mines Corp. continued construction of a new 650-ton-per-day rotary lime kiln at Annville, Pa. Total capacity of 1,350 tons per day will be available for BOF steel manufacture at Bethlehem, Pa., as well as open-market use. CF&I

Table 1.—Salient lime statistics in the United States

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
Number of primary plants	210	212	208	209	206
Sold or used by producers:					
Quicklime	11,370	12,009	13,195	13,438	14,440
Hydrated lime	2,551	2,609	2,669	2,656	2,364
Dead-burned dolomite	2,168	2,176	2,193	1,880	1,833
Total [1]	16,089	16,794	18,057	17,974	18,637
Value [2]	$228,149	$232,939	$239,588	$241,187	$249,639
Average value per ton	$13.87	$13.87	$13.27	$13.42	$13.39
Open-market	9,802	10,449	11,451	11,461	12,054
Captive	6,287	6,345	6,606	6,513	6,583
Exports [3]	30	40	60	52	69
Imports for consumption [3]	123	276	196	123	106

[1] Data may not add to totals shown because of independent rounding.
[2] Selling value, f.o.b. plant, excluding cost of containers.
[3] Source: Bureau of the Census.

---

[1] Mineral specialist, Division of Mineral Studies.

Steel Corp. completed a new 300 ton-per-day vertical lime kiln at its Pueblo, Colo., works. The automated plant provides fluxing lime for two 115-ton BOF steel furnaces.

Major expansions were underway or completed at six other lime plants in 1968. National Gypsum Co.'s new rotary kiln at Kimballton, Va., raised production to nearly 1 million tons per year; Marblehead Lime Co.'s new rotary kiln at Buffington, Ind., raised its capacity to 1,500 tons per day. United States Lime Products Division of The Flintkote Co. added a 300-ton-per-day kiln at its Apex, Nev., plant; Cutler-La Liberte-McDougall Corp. added a 20-ton-per-hour lime hydrating plant at its Superior, Wis., plant. Ash Grove Cement Co. put a 200-ton-per-day rotary-hearth lime kiln onstream at its Springfield, Mo., plant. Ohio Lime Co. added a new 300-ton-per-day Parson's calciner at its Woodville, Ohio, plant for producing dolomitic quicklime.

Modern equipment and plant automation were becoming an important feature of the lime industry. The Paul Lime Plant, Inc., at Paul Spur, Ariz., uses a centralized kiln-control board to record temperatures at all critical points. Installation of a 10 by 150 foot Kennedy Van Saun rotary kiln and preheater upped capacity to 480 tons per day with near perfect thermal efficiency.[2] The new 800-ton-per-day Huron Lime Co. plant at Huron, Ohio, furnishes fluxing lime to the BOF steel furnaces of Weirton Steel Co., at Weirton, W. Va. Materials can be received and shipped by lake transportation, truck, or rail, with self-unloading conveyor systems.[3]

Pete Lien & Sons, Inc., Rapid City, S. Dak., recently added a portable, multilevel, vertical kiln to its lime plant, increasing quicklime capacity from 85 to 350 tons per day, and quadrupling hydrating capacity. Planned is the purchase of an additional similar kiln.[4]

Dixie Lime & Stone Co.'s new 200-ton-per-day rotary hearth Calcimatic kiln at Sumterville, Fla., replaced nine oak-wood

---

[2] Utley, Harry F. Paul Lime Plant Ups Capacity to 480 tpd. Pit and Quarry, v. 60, No. 11, May 1968, pp. 159–161.

[3] Herod, Buren C. Metallurgical Market Spawns New Lime Plant. Pit and Quarry, v. 60, No. 11, May 1968, pp. 123–126.

[4] Lien, Bruce H. Portable Lime Kiln Proves Simple, Inexpensive. Rock Prod., v. 71, No. 7, July 1968, pp. 69, 102–104.

Table 2.—Lime, primary, sold or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	Sold			Used			Total		
	Active plants	Quantity	Value	Active plants	Quantity	Value	Active plants	Quantity	Value
1967									
Alabama	5	504	$5,836	4	120	$1,883	7	624	$7,719
Arizona	3	W	W	4	W	W	7	186	3,142
Arkansas	1	W	W	4	W	W	5	187	2,723
California	6	209	3,735	12	330	4,961	18	539	8,696
Colorado	2	W	W	11	W	W	13	118	2,028
Florida	2	W	W	1	W	W	3	155	2,425
Hawaii	2	W	W	1	W	W	2	8	265
Louisiana	2	W	W	2	W	W	4	758	9,891
Maryland	3	W	W	------	------	------	3	W	W
Massachusetts	3	W	W	1	W	W	3	195	3,044
Michigan	4	810	9,617	8	977	11,965	11	1,787	21,582
Missouri	4	W	W	1	W	W	4	W	W
Montana	------	------	------	4	143	1,765	4	143	1,765
New Mexico	------	------	------	1	17	243	1	17	243
New York	1	W	W	3	W	W	3	1,139	10,570
Ohio	15	W	W	8	W	W	19	3,636	48,817
Oregon	2	W	W	2	W	W	4	99	2,059
Pennsylvania	14	W	W	2	W	W	16	1,719	24,715
Texas	9	843	10,552	6	722	10,161	14	1,564	20,713
Utah	3	W	W	4	W	W	7	169	3,182
Virginia	9	W	W	2	W	W	10	829	10,345
West Virginia	3	W	W	1	W	W	3	217	3,099
Wisconsin	5	211	3,407	1	1	7	6	212	3,414
Connecticut, New Jersey, Vermont	3	W	W	------	------	------	3	W	W
Illinois, Indiana, Iowa, Minnesota, Mississippi, Nebraska, North Dakota, Oklahoma, South Dakota, Tennessee, Wyoming	14	1,641	22,999	15	143	4,044	28	1,784	27,042
Idaho, Nevada, Washington	5	W	W	6	W	W	11	383	6,117
Undistributed [1]	------	7,244	100,642	------	4,059	49,321	------	1,504	17,538
Total [2]	120	11,461	156,787	104	6,513	84,350	209	17,974	241,137
Puerto Rico	1	35	1,106	------	------	------	1	35	1,106
1968									
Alabama	6	W	W	3	W	W	6	773	8,933
Arizona	3	W	W	4	W	W	7	260	4,561
Arkansas	1	72	971	4	134	2,087	5	206	3,058
California	6	210	3,703	11	357	5,598	16	568	9,301
Colorado	2	W	W	12	W	W	13	125	2,375
Florida	3	W	W	1	W	W	3	125	2,059
Hawaii	2	W	W	1	W	W	2	8	268
Louisiana	2	W	W	2	W	W	4	781	10,159
Massachusetts	3	W	W	1	W	W	3	198	3,380
Michigan	4	782	9,469	8	848	10,401	11	1,630	19,870
Montana	------	------	------	4	179	2,005	4	179	2,005
New Mexico	------	------	------	1	27	377	1	27	377
New York	1	W	W	3	W	W	3	1,086	10,154
Ohio	16	W	W	8	W	W	21	3,701	49,367
Oregon	2	W	W	2	W	W	4	120	2,407
Pennsylvania	13	W	W	2	W	W	14	1,702	24,272
Texas	9	828	10,454	6	736	10,701	14	1,564	21,154
Utah	3	W	W	4	W	W	7	174	3,439
Virginia	9	W	W	2	W	W	10	919	11,138
West Virginia	3	W	W	1	W	W	3	207	2,848
Wisconsin	5	224	3,620	------	------	------	5	224	3,620
Connecticut, Maryland, New Jersey, Vermont	6	80	1,360	------	------	------	6	80	1,360
Illinois, Indiana, Iowa, Minnesota, Tennessee, Missouri	15	3,185	39,916	8	87	2,059	20	3,272	41,975
Kansas, Mississippi, Nebraska, North Dakota, Oklahoma, South Dakota, Wyoming	3	144	1,847	10	126	2,415	13	270	4,262
Idaho, Nevada, Washington	5	323	5,738	6	116	1,561	11	439	7,298
Undistributed [1]	------	6,206	88,135	------	3,973	47,225	------	------	------
Total [2]	122	12,054	165,212	104	6,583	84,427	206	18,637	249,639
Puerto Rico	1	39	1,187	------	------	------	1	39	1,187

W Withheld to avoid disclosing individual company confidential data.

[1] Includes items indicated by symbol W.

[2] Data may not add to totals shown because of independent rounding.

fired vertical kilns, producing a total of 45 tons per day. Quicklime is in demand for water clarification and phosphate plant acid neutralization, from which a cattle-feed product, dicalcium phosphate, is manufactured.[5] Sierra Lime Products Corp.'s new rotary-kiln lime plant at Cool, Calif., utilizes undersize limestone waste from a nearby beet-sugar refinery as kiln-feed. Lime is sold for soil and subbase stabilization, or as lump, pebble, and pulverized quicklime.[6]

Kaiser Refractories Co.'s dolomite calcining plant at Natividad, Calif., operates in conjunction with its nearby seawater magnesia plant. Main use of dead-burned dolomite is in manufacture of refractory bricks for lining BOF steel furnaces. Raw material from a nearby dolomite deposit is calcined in three rotary and one rotary-hearth kilns, equipped with heat exchangers.[7]

Table 3.—Regenerated quicklime produced in the United States

(Thousand short tons and thousand dollars)

State	1967		1968	
	Quantity	Value	Quantity	Value
Alabama	381	$5,405	434	$6,824
Arkansas	178	3,488	187	3.615
California	118	2,525	137	3,383
Florida [1]	467	7,625	671	12,144
Georgia	355	6,653	551	10,744
Idaho	73	1,962	76	2,110
Kentucky	242	2,544	214	W
Louisiana	457	9,734	498	10,690
Maine	------	------	122	1,988
Michigan	W	W	39	617
North Carolina	353	3,653	349	4,892
Ohio	92	W	W	W
Oregon	187	4,546	189	4,592
Pennsylvania [1]	23	400	46	803
South Carolina	314	3,184	341	3,459
Tennessee	122	1,920	122	1,993
Virginia	W	W	273	4,176
Washington	414	9,596	437	10,179
Wisconsin [1]	W	W	58	1,035
Undistributed [2]	581	11,496	559	11,639
Total [3]	4,357	74,731	5,303	94,882

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes hydrated lime to avoid disclosing individual company confidential data.

[2] Includes Maryland, Mississippi, Montana, New Hampshire, New York, Texas, and States indicated by symbol W.

[3] Data may not add to totals shown because of independent rounding.

Table 4.—Number and production of domestic lime plants, by size of operation[1]

Annual production (short tons)	1967			1968		
	Number of plants	Production (thousand short tons)	Percent of total	Number of plants	Production (thousand short tons)	Percent of total
Less than 10,000	56	284	2	49	246	1
10,000 to less than 25,000	37	604	3	41	664	4
25,000 to less than 50,000	29	1,020	6	34	1,241	7
50,000 to less than 100,000	29	1,890	10	25	1,761	9
100,000 to less than 200,000	25	2,810	16	25	3,569	19
200,000 and over	33	11,366	63	32	11,156	60
Total	209	17,974	100	206	18,637	100

[1] Includes captive tonnage.

---

[5] Levine, Sidney. Dixie Lime & Stone's Plant Complex Designed To Meet Florida Needs. Rock Prod., v. 71, No. 8, August 1968, pp. 69–73.

[6] Utley, Harry F. New California Lime Plant Obtains Raw Material Without Quarrying or Crushing. Pit and Quarry, v. 61, No. 6, December 1968, pp. 154–158.

[7] Betts, Harold. Kaiser Refractories Expands at Natividad. Miner. Proc., v. 9, No. 11, November 1968, pp. 12–13, 22.

Table 5.—Lime sold or used by producers in the United States, by uses

(Thousand short tons)

Use	1967			1968		
	Open market	Captive	Total	Open market	Captive	Total
Agriculture	174	--------	174	213	--------	213
Construction:						
Finishing lime	231	--------	231	306	--------	306
Mason's lime	518	(1)	518	446	(1)	446
Soil stabilization	669	--------	669	658	--------	658
Other	14	--------	14	11	--------	11
Total [2]	1,433	(1)	1,433	1,422	(1)	1,422
Chemical and other industrial:						
Alkalies (ammonium, potassium, and compounds)	50	3,092	3,142	61	2,940	3,001
Brick, sand-lime, slag, and silica	16	--------	16	18	--------	18
Calcium carbide	419	W	419	463	268	731
Glass	437	--------	437	383	--------	383
Other chemical uses [3]	671	1,277	1,949	748	1,131	2,011
Metallurgical uses:						
Aluminum	143	W	143	137	W	137
Copper smelting	127	170	296	161	207	368
Magnesium	W	W	128	W	W	W
Ore concentration	63	--------	63	73	--------	73
Steel flux	4,005	676	4,681	4,362	666	5,028
Metallurgy (other)[4]	114	302	288	161	203	232
Paper and pulp	878	92	970	893	98	991
Sewage and trade-wastes treatment	322	49	371	374	74	448
Sugar	27	536	563	28	682	710
Water softening and treatment	1,019	4	1,023	1,039	W	1,039
Total [2]	8,290	6,198	14,488	8,900	6,269	15,170
Refractory lime (dead-burned dolomite)	1,565	315	1,880	1,520	318	1,838
Grand total [2]	11,461	6,513	17,974	12,054	6,583	18,637

W Withheld to avoid disclosing individual company confidential data.

[1] Included with "Other chemical uses" to avoid disclosing individual confidential data.

[2] Data may not add to totals shown because of rounding.

[3] Includes calcium carbonate (precipitated), coke and gas, food and food byproducts, insecticides, oil-well drilling, paint, petrochemicals, petroleum refining, rubber, tanning, miscellaneous unspecified uses, mason's lime, and items indicated by symbol W.

[4] Includes various metallurgical uses and items indicated by symbol W.

CONSUMPTION AND USES

Production of fluxing lime for BOF steel production became a substantial part of the lime industry in 1968, as steady growth of Basic-Oxygen-Furnace installations continued. The National Lime Association estimated that over 50 million tons per year of BOF steel capacity was installed in 1968, and that another 20 million tons of capacity now under construction would be completed by 1970. It was also estimated that BOF steel production will represent 55 percent of total domestic steel output in 1970. The use of dolomitic lime as part of the BOF fluxing charge was found to improve the life of dead-burned dolomite refractory linings at Ford Motor Co.'s River Rouge steel plant, Dearborn, Mich. Two 250-ton BOF vessels, making 30 heats per day, reached a record 1,103 heats without relining.[8]

The use of lime and lime-cement for soil and subgrade stabilization continued to grow during 1968, as several important projects were underway. The Dallas freeway project in Texas used a 6- to 8-inch premixed lime soil-cement layer for a subgrade. A portable pugmill plant, traveling disk mixers, and a CMI Autograde unit for spreading and trimming the base and cement pavement completely mechanized the operation.[9] In Eastern North Dakota, a plastic black gumbo clay was treated with lime to form a granular-like subbase material, and tamped into a 6-inch subgrade. Soil testing to determine optimum moisture and lime content was important.[10] Sears, Roebuck & Co. reported admirable results from using lime to stabilize parking lots. The Port of New York Authority announced plans to use lime for stabilizing runways up to 32 inches thick at a Newark, N.J., airport facility. The project includes runways, taxiways, aprons, and parking lots; a total of 50,000 to 80,000 tons of lime will be required.

---

[8] National Lime Association. Limeographs. V. 34, No. 4, January 1968, p. 37.

[9] Roads and Streets. Lime in Subgrade, Cement in Base-How Done for Texas Freeway. V. 111, No. 6, June 1968, pp. 72–74.

Soil stabilization was also applied to irrigation during 1968. The Austin White Lime Co. successfully stabilized an irrigation ditch bottom with hydrated lime near Bastrop, Tex. The new use has potential in irrigated areas, where large amounts of water are annually lost by seepage.[11] Experiments in Australia were also successful in stabilizing irrigation channels with hydrated lime. Pumping, formerly used to regain water from broken channels, can be eliminated. A steady use for lime was expected.[12]

In an important development for agricultural lime producers, agronomists presented evidence that only one-half the aglime needed is being used today. By using lime to correct soil acidity, the potential return of fertilizer mineral applications can be doubled. A 15- to 20-percent increase in agliming was predicted with release of additional land from the soil bank.[13] Effects of limed soils on pine forest growth were studied. Results showed a substantial need for liming in acid soil conditions, for pine and cottonwood forests.[14]

---

[10] Roads and Streets. Lime Stabilization Turns Bad Clay Into Paving Platform. V. 111, No. 8, August 1968, pp. 48–50, 88.

[11] National Lime Association. Limeographs. V. 34, No. 7, April–May 1968, p. 62A.

[12] National Lime Association. Limeographs. V. 34, No. 5, February 1968, p. 46.

[13] Farm Chemicals. Are We Heading for a Lime Barrier? V. 131, No. 9, September 1968, pp. 46–54.

[14] National Lime Association. Limeographs. V. 34, No. 5, February 1968, p. 43.

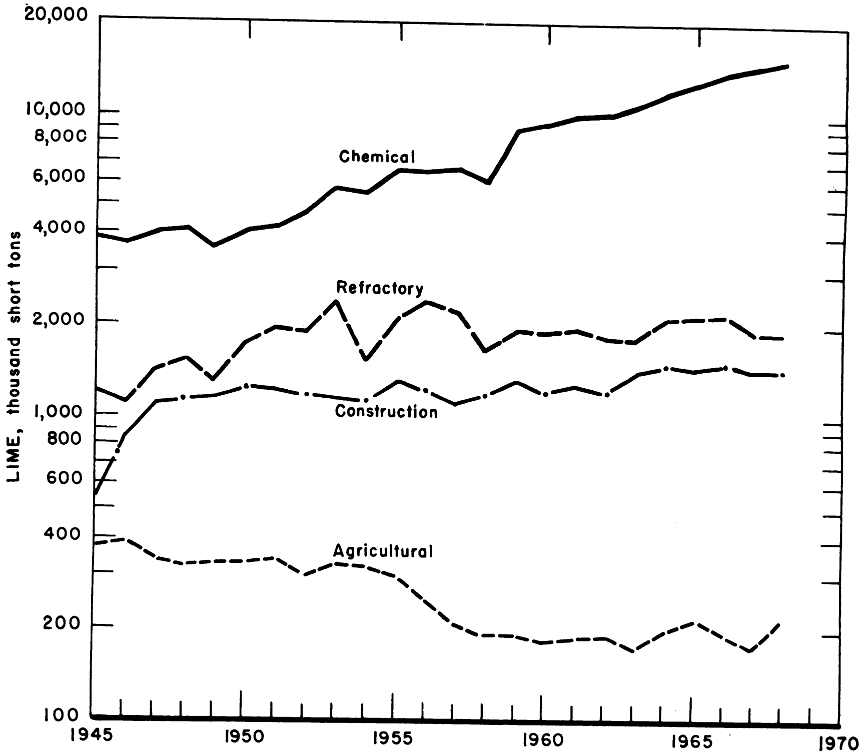

Figure 1.—Trends in major uses of lime.

Table 6.—Destination of shipments of primary open-market lime sold in the United States, by States

(Thousand short tons)

State	1967			1968		
	Quicklime	Hydrated lime	Total	Quicklime	Hydrated lime	Total
Alabama	265	17	282	282	34	316
Alaska	W	W	1	W	W	1
Arizona	W	W	95	W	W	131
Arkansas	12	19	31	34	25	58
California	292	118	409	305	114	419
Colorado	81	25	107	80	19	99
Connecticut	76	24	100	71	25	97
Delaware	27	10	37	32	8	41
District of Columbia	W	W	3	W	W	4
Florida	134	56	190	195	53	249
Georgia	86	17	103	95	20	115
Hawaii	W	W	W	W	W	W
Idaho	W	W	13	W	W	11
Illinois	607	161	768	619	160	780
Indiana	1,084	65	1,149	1,072	68	1,140
Iowa	71	25	96	62	30	91
Kansas	40	18	56	42	40	82
Kentucky	495	18	513	571	17	588
Louisiana	151	64	215	165	68	233
Maine	50	11	61	48	12	60
Maryland	331	16	348	346	17	364
Massachusetts	W	W	37	W	W	27
Michigan	866	59	925	849	56	905
Minnesota	112	15	127	110	15	126
Mississippi	76	15	91	84	22	106
Missouri	144	34	178	144	39	183
Montana	11	2	13	4	2	5
Nebraska	W	W	18	10	11	21
Nevada	W	W	29	42	3	45
New Hampshire	W	W	11	8	4	12
New Jersey	59	80	139	73	95	168
New Mexico	1	25	25	39	35	74
New York	233	166	398	218	164	382
North Carolina	78	31	110	87	33	121
North Dakota	W	W	27	10	18	28
Ohio	1,331	136	1,466	1,468	137	1,605
Oklahoma	W	W	W	62	45	107
Oregon	46	16	62	61	19	80
Pennsylvania	1,137	165	1,303	1,114	176	1,290
Rhode Island	7	7	14	W	W	16
South Carolina	54	8	62	49	9	58
South Dakota	20	26	46	12	34	47
Tennessee	73	52	125	95	42	136
Texas	391	510	901	392	444	835
Utah	W	W	81	63	14	77
Vermont	W	W	2	W	W	2
Virginia	86	33	120	84	34	117
Washington	60	15	75	57	20	77
West Virginia	96	16	112	222	20	242
Wisconsin	86	62	147	113	56	169
Wyoming	W	W	8	W	W	W
Undistributed [1]	278	173	125	109	96	18
Total United States [2]	9,046	2,312	11,357	9,597	2,350	11,947

W Withheld to avoid disclosing individual company confidential data.

[1] Includes States indicated by symbol W.

[2] Data may not add to totals shown because of independent rounding.

The cost and availability of transportation as it affects lime consumption was the subject of an article by The National Lime Association Traffic Committee.[15] Truck axle-weight laws, rail freight-rate increases, and care of products in-transit, all of which have a direct bearing on the practicality, or added cost, of using lime in any given area were discussed.

A new development in water-softening treatment proved successful at the Ames, Iowa, municipal water plant. A novel split-treatment bypass and recirculation system required less lime and soda ash, and produced better quality water. Savings of 15 percent in chemical costs amounted to a $5-per-million-gallon cost reduction.[16]

---

[15] Heeman, R. F. Transportation and the Lime Industry. Pit and Quarry, v. 60, No. 11, May 1968, pp. 163–167.

[16] National Lime Association. Limeographs. V. 34, No. 4, January 1968, p. 37.

PRICES

Quotations in the Engineering News-Record for delivered hydrated finishing lime in 1968 ranged from $62 per ton in Seattle to $27 per ton in Los Angeles. The average price reported for 16 major cities was $42.51 per ton. Prices for pulverized quicklime ranged from $64 per ton in Seattle to $26 per ton in Dallas, and averaged $39.52 per ton for 10 cities; the same prices held for common lump lime. The average delivered price for common hydrated lime, as reported from 15 selected cities, was $35.12 per ton.

The average value of lime sold or used by producers, f.o.b. plant, excluding the cost of containers, was $13.39 per ton, compared with $13.42 in 1967.

FOREIGN TRADE

In 1968, Canada received 66 percent of U.S. lime exports and Mexico received 21 percent. Imports from Canada represented virtually all of the combined import total for all types of lime in 1968.

Table 7.—U.S. exports of lime

Year	Short tons	Value (thousands)
1966	59,848	$1,195
1967	52,143	1,099
1968	68,915	1,487

Table 8.—U.S. imports for consumption of lime

Year	Hydrated lime		Other lime		Dead-burned dolomite [1]		Total	
	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)	Short tons [2]	Value (thousands)
1966	208	$5	151,703	$1,772	43,637	$2,038	195,543	$3,815
1967	545	12	79,983	961	42,413	1,832	122,941	2,805
1968	873	21	71,632	877	33,498	1,552	106,003	2,450

[1] Dead-burned basic refractory material consisting chiefly of magnesia and lime.
[2] Includes weight of immediate container.

WORLD REVIEW

Dominican Republic.—The single, oil-fired, shaft kiln, 40-ton-per-day lime plant of Industrias Nigua, near Santo Domingo, provided hydrated lime for the sugar processing industry. Stone was quarried by pry bar, handsorted, and crushed by sledge hammer.

South Africa, Republic of.—Northern Lime Co. Ltd., installed an 11½- by 375-foot rotary kiln at its Silver Streams plant, 90 miles from Kimberley. Total production of this plant and a plant at Buxton is 3,500,000 tons per year, making Northern Lime Co. Ltd. one of the largest lime and limestone operations in the world.

United Kingdom.—Use of aglime has dropped by 40 percent, to 4.5 million tons per year. However, Soil Fertility Dunns, Ltd., at Bath, Somerset, reported quadrupled sales of aglime during the last 10 years, making it the largest supplier of aglime, agstone, chalk, and liquid fertilizers in Britain.[17]

---

[17] Pit and Quarry. Aglime Firm Expands Trading While Britain's Consumption Falls by 40 Percent. V. 61, No. 1, July 1968, pp. 188–191.

Table 9.—World production of quicklime and hydrated lime, including dead-burned dolomite, sold or used

(Thousand short tons)

Country [1]	1964	1965	1966	1967	1968 ^{p}
North America:					
Canada	1,541	1,620	^{r} 1,555	1,423	1,366
Costa Rica ^{e}	7	13	13	9	9
Guatemala	NA	20	19	21	19
Nicaragua	29	29	30	^{e} 31	^{e} 33
Puerto Rico	18	27	30	35	39
United States (sold or used by producers)	16,089	16,794	18,057	17,974	18,637
South America:					
Brazil	1,586	1,344	1,400	1,494	NA
Colombia	110	119	56	965	1,008
Paraguay	20	20	19	19	20
Uruguay ^{e}	46	66	66	77	66
Venezuela	75	71	49	NA	NA
Europe:[2]					
Austria	805	763	765	751	644
Belgium	2,534	2,526	2,460	2,518	NA
Bulgaria	919	938	966	^{e} 981	^{e} 992
Czechoslovakia	2,587	^{r} 2,651	^{r} 2,617	2,604	NA
Denmark	176	179	165	209	^{e} 209
Finland	265	270	250	254	231
France	^{r} 4,087	^{r} 4,030	^{r} 4,150	4,187	4,417
Germany:					
East	4,049	3,793	^{r} 4,037	3,901	NA
West	11,920	11,714	11,465	11,180	11,722
Hungary	811	782	852	882	808
Ireland	44	^{e} 46	45	46	69
Italy ^{e}	5,622	5,622	5,622	5,401	5,512
Norway	114	251	^{r} 258	211	220
Poland	2,395	2,491	2,647	2,599	^{e} 2,756
Rumania	1,146	1,132	1,154	1,157	1,157
Spain	^{r} 346	^{r} 394	277	^{e} 331	^{e} 331
Sweden	948	967	^{r} 923	984	^{e} 992
Switzerland	221	195	184	169	162
U.S.S.R.	17,855	^{r} 19,526	^{r} 20,804	21,661	^{e} 22,046
Yugoslavia	999	1,226	1,255	1,322	1,323
Africa:					
Congo (Kinshasa)	75	72	^{r} 69	NA	NA
Ethiopia (including Eritrea)	^{e} 7	^{e} 4	^{r} 30	25	25
South Africa, Republic of (sales)	771	823	812	964	914
South-West Africa, Territory of	4	4	3	NA	NA
Tanzania	2	2	10	6	7
Tunisia	193	^{e} 192	190	187	^{e} 187
Uganda	13	22	4	204	NA
Zambia	NA	85	NA	77	79
Asia:					
Cyprus	^{e} 44	81	^{e} 84	^{e} 90	^{e} 94
India	NA	NA	NA	NA	313
Japan	1,798	1,865	2,219	3,397	3,996
Kuwait	13	1	1	1	1
Lebanon ^{e}	29	44	72	55	99
Mongolia ^{e}	33	39	39	44	44
Philippines	32	26	26	93	116
Ryukyu Islands	NA	NA	23	1	NA
Saudi Arabia	8	^{r} 9	^{r} 10	7	8
Taiwan	101	113	118	102	143
Oceania:					
Australia [3]	113	178	167	^{e} 176	NA
Fiji Islands	4	4	3	3	4
Total [4]	^{r} 80,604	^{r} 83,183	^{r} 86,070	88,828	80,818

^{e} Estimate. ^{p} Preliminary. ^{r} Revised. NA Not available.

[1] Lime is produced in many other countries of the world besides those listed. Mexico and United Kingdom are among the more important countries for which official data are unavailable.

[2] For Europe the data includes lime only and in the case of France, high grade lime only. France's total lime production is much larger than that shown.

[3] Year ended June 30 of year stated.

[4] Total is of listed figures only.

TECHNOLOGY

The reactions of hydrated lime and fly ash mixtures in forming pozzolanic cements were detailed in a series of articles. Chemical reactions were found to vary with size fractions, trace impurities in the materials, dolomite and water content of the lime, and chemical and mineral composition of the fly ashes. Conditions of curing were studied through X-ray, microscope, and Differential Thermal Analysis examination. An extremely complex chemistry results from these pozzolanic reactions.[18]

Refractory manufacturers met stricter demands from the steelmakers by emphasizing technology in 1968. Research on dolomite bricks has made them increasingly popular for BOF linings. Increasing the life of BOF linings has lowered steelmaking costs; with standard life growing from 90 to 800 or 1,000 heats per lining. Dolomite refractory costs on BOF's were quoted as low as $0.50 per ton of steel. Although less dolomite bricks are needed with the greatly increased lining life, new types of brick refractories and replacement of silica, clay and basic brick uses by dolomite-brick is increasing the demand for dolomite refractories.[19]

Operation of the new Azbe Super Rotary Kiln was described.[20] This unusually short kiln has a high thermal efficiency and will produce twice the amount of lime as the average kiln. A 9¾- by 175-foot kiln is rated at 500 tons per day.

Other important technical developments during the year include a process for precipitating fluoride wastes from glass manufacture with hydrated lime. These wastes result from use of hydrofluoric acid for frosting glass. Kent Feeds, Muscatine, Iowa, was doing research on a process for recovering sulfuric acid, plus byproduct lime from gypsum raw materials. A fluidized-bed reactor is employed at 220° F in an experimental plant.

Chemical reactions in making soda-lime glass were investigated. Titania, germania, zirconia, and alumina were substituted for part of the silica content and a more chemically durable glass resulted.[21]

---

[18] Minnick, John L. Reactions of Hydrated Lime With Pulverized Coal Fly Ash. Miner. Proc. Part I, v. 9, No. 2, February 1968, pp. 15–20. Part II, v. 9, No. 3, March 1968, pp. 12–19.

[19] Malim, T. H. Less Brick for More Hot Metal. Iron Age, v. 202, No. 15, Oct. 10, 1968, pp. 69–76.

[20] Azbe, Victor J. Super Rotary Kiln Revisited. Rock Prod., v. 71, No. 7, July 1968, pp. 61–63, 106.

[21] Book T., C. F. Rapp, H. T. Hartley, and B. E. Wiems. Chemical Durability of a Soda-Lime Glass with TiO_2, GeO_2, ZrO_2, and $AlPO_4$, Partially Substituted for SiO_2. Amer. Ceram. Soc. Bull., v. 47, No. 8, August 1968, pp. 727–730.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/51

Magnesium

By John W. Cole[1]

There was a general shortage of magnesium metal in 1968; plans were announced for expansion of domestic magnesium production; and construction was started on one new electrolytic plant.

Legislation and Government Programs.—Under a new law (Public Law 90–604 October 18, 1968) the General Services Administration (GSA) was authorized to dispose of 55,000 short tons of surplus magnesium from the national stockpile. Of 5,000 tons advertised for sale by GSA on October 28, acceptable bids were received for only about 3,000 tons, indicating that the midyear shortage had been alleviated. Following the first sale, GSA on December 10 announced the additional offering of 10 million pounds of surplus magnesium for sale on a competitive bid basis, with bids to be opened January 9, 1969.

Table 1.—Salient magnesium statistics

(Short tons)

	1964	1965	1966	1967	1968
United States:					
Production:					
Primary magnesium	79,488	81,361	79,794	97,406	98,375
Secondary magnesium	11,790	13,617	15,129	13,444	[e] 14,894
Shipments: Primary	74,580	85,796	96,443	100,743	103,671
Exports	15,949	17,836	14,869	11,989	18,364
Imports for consumption	2,227	2,551	3,265	9,235	4,086
Consumption	54,748	69,622	82,678	90,775	86,427
Price per pound cents	35.25	35.25	35.25	35.25	35.25
World: Primary production	165,878	178,318	179,894	205,069	[e] 207,089

[e] Estimate.

DOMESTIC PRODUCTION

Domestic production of 98,400 tons of primary magnesium exceeded 1967 production by less than 1,000 tons. The Dow Chemical Co. operated electrolytic plants at Freeport and Velasco, Tex. The Alamet Division of Calumet and Hecla, Inc., operated a silicothermic plant at Selma, Ala.

American Magnesium Co. started construction of an electrolytic magnesium plant at Snyder, Tex., to recover magnesium and chlorine from well brines. The first unit, with a planned capacity of 10,000 tons per year, is scheduled to start production in June 1969. Ultimate capacity of the plant was announced to be 30,000 tons per year of magnesium.

Great Salt Lake Minerals & Chemicals Corp. (owned by Gulf Resources and Chemical Corp., 49 percent, and by Salzdetfurth/AG. Hanover, West Germany, 51 percent) contracted to supply The Dow Chemical Co. with a yearly minimum of 100,000 tons of magnesium chloride for 15 years from Great Salt Lake brines. Adjoining plants to produce magnesium chloride for electrolytic cell feed will be built by Great Salt Lake Minerals & Chemicals Corp. and The Dow Chemical Co. near Great Salt Lake.

National Lead Co. and Hogle Kearns Co. magnesium project in Utah settled a 2-year-long dispute over low-cost power and met with favorable court rulings involving financing of its proposed plant. Negotiations with Utah Power and Light Co. concluded with an agreement for a supply of interruptible power at 3.1 mills per kilowatt-hour. The Utah Supreme Court ruled that it was constitutional for Tooele County to issue tax-exempt industrial revenue bonds to finance construction of the project's plant which would be leased to the project. However, a high official of National Lead stated in December that all phases of the project were being reviewed carefully.

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Magnesium recovered from scrap processed in the United States, by kinds of scrap and forms of recovery

(Short tons)

	1964	1965	1966	1967	1968
Kind of scrap:					
New scrap:					
Magnesium-base	4,505	6,306	6,462	5,062	7,006
Aluminum-base	3,177	3,643	4,127	4,266	[e]4,500
Total	7,682	9,949	10,589	9,328	[e]11,506
Old scrap:					
Magnesium-base	2,998	2,232	3,321	2,973	2,113
Aluminum-base	1,110	1,436	1,219	1,143	[e]1,275
Total	4,108	3,668	4,540	4,116	[e]3,388
Grand total	11,790	13,617	15,129	13,444	[e]14,894
Form of recovery:					
Magnesium alloy ingot	2,875	2,138	5,202	3,760	2,502
Magnesium alloy castings (gross weight)	37	14	24	39	15
Magnesium alloy shapes	50	58	70	103	82
Aluminum alloys	4,468	7,947	6,336	6,157	[e]9,269
Zinc and other alloys	23	23	17	18	18
Chemical and other dissipative uses	588	542	281	25	64
Cathodic protection	3,749	2,895	3,199	3,342	2,944
Total	11,790	13,617	15,129	13,444	[e]14,894

[e] Estimate.

[1] Figures include secondary magnesium content of both secondary and primary magnesium alloy ingot.

CONSUMPTION AND USES

Consumption of magnesium decreased 5 percent in 1968 to 86,400 tons. Structural products accounted for 27 percent of consumption and distributive or sacrificial uses accounted for 73 percent. Use in die castings decreased 12 percent to 7,300 tons. As in 1967 aluminum alloys accounted for the largest use of magnesium, 40 percent of total consumption. A contract to supply the U.S. Army with 440,000 magnesium dry cell batteries was awarded to Clevite Corp.'s Burgess Battery Division and Gould National's Marathon Battery Division with the quantity divided equally between the two companies. The magnesium content of the batteries was estimated to be one-fourth to one-half pound each, or about 20 percent of the weight of zinc used in comparable batteries. The batteries will be primary and non-rechargeable. They will cost between $10 and $10.50 each.

Table 3.—Consumption of primary magnesium (ingot equivalent and magnesium content of magnesium-base alloys) in the United States, by uses

	1964	1965	1966	1967	1968
For structural products:					
Castings:					
Sand	2,229	2,959	3,961	r 3,848	3,740
Die [1]	4,757	5,599	4,980	r 8,366	7,337
Permanent mold	732	814	682	r 555	607
Wrought products:					
Sheet and plate	4,897	4,937	6,075	W	W
Extrusions (structural shapes, tubing)	4,419	[2] 5,995	[2] 7,100	r [3] 10,517	[3] 11,280
Forgings	293	W	W	W	W
Total	17,327	20,304	22,748	r 23,286	22,964
For distributive or sacrificial purposes:					
Powder	W	W	W	W	W
Aluminum alloys	21,880	26,266	30,862	31,244	34,484
Zinc alloys	99	136	100	53	52
Other alloys	1,705	2,216	1,975	2,370	W
Scavenger and deoxidizer	141	170	195	W	W
Chemical	2,684	3,806	4,604	5,214	W
Cathodic protection (anodes)	4,983	4,597	4,670	r 4,855	5,714
Reducing agent for titanium, zirconium, hafnium, uranium, and beryllium [4]	3,764	8,467	8,429	6,704	6,209
Other [5]	2,165	3,660	9,095	r 17,049	17,004
Total	37,421	49,318	59,930	r 67,489	63,463
Grand total	54,748	69,622	82,678	r 90,775	86,427

W Withheld to avoid disclosing individual company confidential data. r Revised.

[1] Includes primary metal to produce small quantities of investment castings.

[2] Includes "Forgings."

[3] Includes "Sheet and plate" and "Forgings."

[4] Quantity used for reduction of uranium not included in 1964.

[5] Includes primary metal for experimental purposes, debismuthizing lead, and producing nodular iron, secondary magnesium alloys, other alloys, scavengers and deoxidizers, deoxidizers, chemicals and powder.

PRICES

The quoted base price of primary magnesium, in 10,000-pound lots, 42-pound slabs, 99.8 percent magnesium, continued throughout the year at 35.25 cents per pound f.o.b. U.S. plants. GSA accepted bids ranging from 28.28 to 33.519 cents for surplus magnesium from the national stockpile.

STOCKS

On December 31, 1968, producer and consumer stocks were 7,735 short tons of primary magnesium and 2,205 tons of primary magnesium alloy ingot, a decrease of 3,016 tons of primary magnesium and an increase of 83 tons of primary magnesium alloy ingot, from stocks a year earlier.

Table 4.—Stocks and consumption of new and old magnesium scrap in the United States in 1968

(Short tons)

Scrap item	Stocks Jan. 1 r	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Cast scrap	525	2,334	108	2,580	2,688	171
Solid wrought scrap [1]	2,629	7,262	8,448	-------	8,448	1,443
Total	3,154	9,596	8,556	2,580	11,136	1,614

r Revised.

[1] Includes borings, turnings, drosses, etc.

FOREIGN TRADE

Exports of magnesium increased 53 percent over 1967 levels. Exports to West Germany increased 73 percent and amounted to 66 percent of total exports.

Imports for consumption of magnesium in all forms decreased to 50 percent of 1967 imports. Of total imports of about 4,800 tons, Canada supplied 80 percent; of the remainder the United Kingdom supplied 7 percent and 17 different countries supplied the remaining 13 percent.

The import duty on magnesium was lowered from 40 to 36 percent ad valorem on January 1, 1968, in accordance with the Kennedy Round trade agreements. The duty on unwrought alloys was lowered from 16 cents per pound plus 8 percent ad valorem, to 14.4 cents per pound plus 7 percent ad valorem; and the duty on wrought magnesium was lowered from 13.5 cents per pound plus 7 percent ad valorem, to 12 cents per pound plus 6 percent ad valorem.

Table 5.—U.S. exports of magnesium, by classes and countries

Destination	1967				1968			
	Primary metals, alloys, and scrap		Semifabricated forms, n.e.c. including powder		Primary metals, alloys, and scrap		Semifabricated forms, n.e.c. including powder	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	124	$66	12	$10	142	$62	------	------
Australia	45	25	28	98	160	90	25	$77
Belgium-Luxembourg	8	10	26	39	37	26	45	71
Brazil	868	455	550	290	1,887	958	([1])	([1])
Canada	1,465	962	203	787	1,393	818	435	843
France	97	73	23	56	129	72	12	49
Germany, West	6,999	3,944	4	12	12,113	6,797	2	7
India	128	75	------	------	6	3	1	3
Israel	8	9	23	47	13	9	35	55
Italy	310	163	23	42	227	144	24	49
Japan	95	54	69	165	28	16	57	110
Mexico	353	245	59	76	469	339	117	107
Netherlands	5	9	24	75	57	56	131	649
Norway	89	50	1	4	134	75	2	7
Spain	222	124	1	2	132	74	1	([1])
Sweden	33	24	23	76	49	26	21	60
United Kingdom	718	524	21	72	1,153	950	21	57
Venezuela	149	128	45	44	177	155	92	78
Other	273	192	49	88	58	49	72	108
Total	11,989	7,132	1,184	1,983	18,364	10,719	1,093	2,330

[1] Less than ½ unit.

Table 6.—U.S. exports and imports for consumption of magnesium

Year	Exports			
	Metal and alloys in crude form and scrap		Semifabricated forms n.e.c.	
	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	14,869	$8,853	579	$1,387
1967	11,989	7,132	1,184	1,983
1968	18,364	10,719	1,093	2,330

Year	Imports					
	Metallic and scrap		Alloys (magnesium content)		Powder, sheets, tubing, ribbons, wire, and other forms (magnesium content)	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	3,265	$1,613	689	$1,656	5	$36
1967	[r] 9,235	[r] 4,920	354	1,529	[r] 132	[r] 422
1968	4,086	2,219	705	1,129	25	416

[r] Revised.

WORLD REVIEW

World production 1968 continued at about the same level as in 1967. The United States produced about 50 percent of the estimated world total of 207,000 tons.

World producers of magnesium with capacities, processes, and plant locations are listed below:

Canada.—Dominion Magnesium, Ltd., the only Canadian producer, announced in April that its plant was in full production from 16 furnaces. The company had confirmed orders for 13 million pounds of magnesium and alloys which was sufficient to require full production for the remainder of the year.

Italy.—Compagnia Generale del Magnesio was planning to build a $12.8 million primary magnesium plant near Syracuse on the east coast of Sicily. Although Italy is the largest Common Market producer of magnesium metal, it exports a large part of its production to the European Economic Community (EEC) and has no surplus available to meet anticipated expansion of domestic demand. Fiat is expected to increase use of magnesium in its future operations.

Country	Company	Capacity	Process	Plant location
Canada	Dominion Magnesium Ltd	11,300	Silicothermic	Haley, Ontario.
China, mainland	NA	1,000		
France	Pechiney (35 percent) Compagnie de Produits Chimique et Electrometallurgiques, (35 percent) and Societe des Produits Azotes (SPA) (30 percent).	3,900	Silicothermic	Marignac.
Italy	Societa Italiana per il Magnesio e Leghe di Magnesio.	7,000	--------------	Bolzano.
Japan	Furukawa Magnesium Co. Ltd	6,600	Silicothermic	
	UBE Industries, Ltd	2,200	do	Yamaguchi.
Norway	Heroya Electrojemiske Fabrikker A/S, subsidiary of Norsk Hydro-Elektrist A/S.	37,400	I.G. Farben-indlstrie	Meroya.
U.S.S.R.	NA	50,000	NA.	
United States	The Dow Chemical Co	95,000	Dow cells	Freeport, Tex.
	Alamet Division, Calumet & Hecla, Inc	9,000	Silicothermic	Selma, Ala.
	Titanium Metals Corporation of America.	12,000	I.G. Farben-Industrie.	Henderson, Nev.

NA Not available.

Table 7.—World production of primary magnesium, by countries

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
Canada	9,353	10,108	6,723	[r] 8,887	9,878
China, mainland [1]	1,000	1,000	1,000	1,000	1,000
France	1,090	3,132	3,770	[r] 4,590	[e] 4,600
Germany, West [2]	550	550	220	220	----------
Italy	6,645	6,959	[r] 7,182	6,963	[e] 7,000
Japan [3]	3,237	4,172	5,832	7,438	6,236
Norway	[r] 24,251	29,100	[r] 31,228	33,565	[e] 35,000
U.S.S.R. [e]	35,000	36,000	40,000	45,000	45,000
United Kingdom [4]	5,264	5,936	4,145	----------	----------
United States	79,488	81,361	79,794	97,406	98,375
Total [5]	165,878	178,318	179,894	205,069	207,089

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Conjectural, denoting an order of magnitude.

[2] Estimate according to the 54th annual issue of Metal Statistics (Metallgesellschaft), except for 1967.

[3] In addition, the following amounts of secondary magnesium were produced: 1964, 2,248; 1965, 4,164; 1966, 5,223; and 1967, 7,206 metric tons.

[4] Primary production suspended June 1966.

[5] Totals are of listed figures only.

TECHNOLOGY

Interest continued at a high level in two separate but related problems in the electrolytic winning of magnesium. The first is purification and dehydration of magnesium chloride from evaporated brines; and second, design of electrolytic cells and fused salt electrolytes.

Research continued on purification and dehydration of magnesium chloride from Great Salt Lake and well brines. Bureau of Mines research in this field was centered at its Salt Lake City Metallurgy Research Center. A patent[2] was issued to Bureau of Mines researchers on a process for removing sulfate from brines.

Two patents were issued on methods of producing magnesium and chlorine from magnesium chloride by electrolysis of a fused salt bath. In the first patent[3] a molten salt bath consisting of 5 to 25 percent magnesium chloride, 5 to 55 percent lithium chloride, and at least one other chloride of alkali and alkaline-earth metals is used. It differs from the Dow patented lithium chloride cell in that the bath has a density greater than molten magnesium at operating temperature, so the magnesium floats instead of sinking. The second patent[4] describes a continuous process wherein essentially anhydrous magnesium chloride is added to molten salt in a melt cell, discharged to a charging cell, and thence through a feeder manifold to electrolysis cells having overflow outlets for establishing and maintaining the level of the fused electrolyte. The overflow, containing magnesium and fused electrolyte, is carried through closed conduits to a refining cell where the metal is separated and the electrolyte returned to the charging cell.

A paper[5] was published on methods of melting and handling magnesium for die casting. A direct melting method is described that reportedly lowers costs to 58 percent of that using the conventional method.

An experimental, boron fiber-reinforced magnesium panel was described.[6] Experimental magnesium-boron composites containing 30 percent by volume of boron filaments had higher specific strength properties than any material currently used for aerospace structures. Magnesium is chemically compatible with boron so there was little degradation of filament properties during fabrication. Tensile strength was 138,000 and 110,000 pounds per square inch, at room temperature and at 750° F, respectively.

---

[2] George, D'Arcy R., and James M. Riley (assigned to U.S. Department of the Interior). Sulfate Removal From Brines. U.S. Pat. 3,378,336, June 16, 1968.

[3] Love, Frank E. (assigned to National Lead Co.) Electrolytic Production of Magnesium Metal from a Fluoride-Free Bath. U.S. Patent 3,389,062, June 18, 1968.

[4] Love, Frank E. (assigned to National Lead Co.) Continuous Process for Producing Magnesium Metal from Magnesium Chloride Including Fused Bath Electrolysis. U.S. Patent 3,418,223, Dec. 24, 1968.

[5] P. H. Krohn, Latest Methods for Melting and Handling of Magnesium for Die Casting. Light Metal Age, Nos. 11–12, November–December 1968.

[6] Materials Engineering. V. 67, No. 1, January 1968, p. 58.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/180

Magnesium Compounds

By John W. Cole [1]

The increase in production of magnesia from sea water continued to exert competitive pressure on producers of magnesite. Operation of a new magnesia-from-seawater plant was started on the west coast of Newfoundland, and construction was initiated on a similar plant in Ireland. On the other hand, one of the two active magnesite mining operations in the United States was closed.

Table 1.—Salient magnesium compounds statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Caustic-calcined and specified magnesias:[1]					
Shipments:					
Quantity	84	90	99	114	135
Value	$8,562	$9,163	$9,686	$11,250	$12,226
Imports for consumption:[2]					
Value	$493	$592	$743	$585	$758
Exports:[2]					
Value	$1,654	$1,637	$1,627	$2,095	$2,301
Refractory magnesia:					
Sold and used by producers:					
Quantity	842	897	852	688	661
Value	$49,220	$56,100	$52,290	$43,148	$44,535
Exports:					
Value	$5,554	$5,912	$6,208	$5,889	$4,706
Imports:					
Value	$3,180	$4,214	$8,139	$5,171	$6,179
Dead-burned dolomite:					
Sold and used by producers:					
Quantity	2,168	2,176	2,193	1,880	1,833
Value	$37,961	$39,606	$39,725	$34,083	$31,627
Imports:					
Value	$1,165	$2,385	$2,038	$1,832	$1,552
World: Crude magnesite:					
Production: Quantity	10,516	11,072	11,106	11,339	11,145

[1] Excludes caustic-calcined magnesia used in production of refractory magnesia.
[2] Caustic-calcined magnesia only.

DOMESTIC PRODUCTION

Nevada and Washington supplied all of the crude magnesite produced in 1968. Basic, Inc., the only producer in Nevada, also reported some production of brucite from its Gabbs, Nev., property. The Northwest Magnesite Co. operation at Chewelah, Wash., was shut down in mid-1968, as scheduled because of competition from lower cost imported magnesium products. Northwest Magnesite Co. is a subsidiary of Harbinson-Walker Refractories Co. which merged with Dresser Industries, Inc. in 1967.

Approximately 87 percent of the dead-burned dolomite was produced in Ohio, Illinois, Louisiana, Pennsylvania, and West Virginia. Crude olivine was produced in Washington and North Carolina. Total production was about the same as 1967.

---

[1] Physical scientist, Division of Mineral Studies.

Michigan led in the production of refractory magnesia from well brines, sea water, or dolomite. Refractory magnesia from the same sources also was produced in California, Florida, Mississippi, New Jersey, and Texas. Nevada led in the production of refractory magnesia from magnesite and brucite; Washington was second.

Producers sold 332,620 tons of refractory magnesia in 1968 and consumed 328,271 tons in their own plants for a total production of 660,891 tons valued at $44.5 million, compared with 687,705 tons in 1967 valued at $43.1 million. The unit value of shipments was applied to producers consumption to calculate a total value.

Production of hydrous magnesium sulfate declined 10 percent and magnesium trisilicate 53 percent. Small quantities of magnesium nitrate, magnesium phosphate, magnesium acetate and anhydrous magnesium sulfate also were produced.

The Port St. Joe facilities of Michigan Chemical Corp. were purchased by Basic, Inc., for about $1.25 million. The plant has an annual capacity of 60,000 tons of refractory and chemical grade magnesia from sea water and lime.

Standard Lime and Magnesia, subsidiary of Martin Marietta Corp., installed facilities at its Manistee, Mich., plant for production of a complete line of caustic-calcined magnesias. Also it installed a new shaft kiln for production of plus 98 percent MgO periclase.

FMC Corp. announced that its Inorganic Chemical Division was trying to sell its magnesium oxide plant in Newark, Calif. No buyer was found and the operation was closed down at yearend. The plant employed about 125.

Table 2.—Dead-burned dolomite sold in and imported into the United States

(Thousand short tons and thousand dollars)

Year	Sales of domestic product		Imports	
	Quantity	Value	Quantity	Value
1964	2,168	$37,961	29	$1,165
1965	2,176	39,606	55	2,385
1966	2,193	39,725	44	2,038
1967	1,880	34,083	42	1,832
1968	1,833	31,627	33	1,552

CONSUMPTION AND USES

Consumption of refractory magnesia, both single-burned and double-burned, decreased 4 percent to 660,891 tons. The decrease was due to technologic improvements in the steel industry that are lowering the quantities of refractory used per unit of steel production.

Consumption of caustic calcined magnesia, excluding consumption as an intermediate material in the production of refractory magnesia, increased 20 percent to 126,000 tons.

Most of magnesium hydroxide was consumed in production of other magnesium compounds and magnesium metal. About 67,000 tons, however, was shipped to other industries including wood pulp mills.

Consumption of hydrous magnesium sulfate increased 6 percent; that of magnesium trisilicate decreased 49 percent. Consumption of anhydrous magnesium chloride, principally for the production of magnesium metal, increased 3 percent, and hydrous magnesium chloride increased 11 percent.

Consumption of olivine, used principally in molding sand mixtures, decreased 1 percent.

Table 3.—Magnesium compounds shipped and used in the United States

Year and product	Plants	Shipped and used	
		Short tons	Value (thousands)
1967:			
Refractory magnesia [1]	12	687,705	r $43,148
Caustic-calcined [2] and Specified (U.S.P. and technical) magnesias	10	114,247	11,250
Magnesium hydroxide (100 percent $Mg(OH)_2$)[2]	r 9	65,463	2,688
Magnesium chlorides [3]	6	[3] 382,929	26,396
Precipitated magnesium carbonate [2]	5	r 8,563	NA
1968:			
Refractory magnesia [1]	12	660,891	$44,535
Caustic-calcined [2] and Specified (U.S.P. and technical) magnesias	10	135,469	12,226
Magnesium hydroxide (100 percent $Mg(OH)_2$)[2]	9	67,043	2,475
Magnesium chlorides [3]	6	[3] 394,287	27,147
Precipitated magnesium carbonate [2]	5	8,791	NA

r Revised. NA Not available.

[1] Includes both single-burned and double-burned.

[2] Excludes material produced as an intermediate step in the manufacture of other magnesium compounds.

[3] Production for 1967, 389,636 tons; 1968, 409,795; includes magnesium chloride used in production of magnesium metal.

Table 4.—Domestic consumption of caustic-calcined magnesia and specified magnesias by uses

(Percent)

Use	1967	1968
Chemical processing	10	11
Fertilizer	4	6
85-percent MgO insulation	1	1
Oxychloride and oxysulfate cements	10	10
Pulp and paper	13	12
Rayon	12	10
Rubber	11	8
Other: Electrical, medicinal, flux, ceramic, glass, sugar, animal feed, fuel additive, water treatment, and uranium processing	39	42

PRICES

Prices were unchanged for all grades of magnesia and dead-burned magnesia, according to the Oil, Paint and Drug Reporter. The price of magnesium sulfate, technical, 100-pound bags, carlots, works, increased from $2.45 to $2.71. U.S.P. crystalline grade in carlots increased from $2.65 to $2.92. Both quotations were increased on October 7.

FOREIGN TRADE

Exports of dead-burned magnesite and magnesia declined 11 percent, continuing the downward trend started in 1965. Deliveries to Canada and Venezuela increased, but deliveries to Mexico decreased about 40 percent.

Imports of lump or ground caustic-calcined magnesia increased 30 percent. Imports of dead-burned and grain magnesia and periclase (containing not over 4 percent lime) increased 14 percent but the same category containing over 4 percent lime decreased 21 percent. Total imports were only 1 percent higher than those in 1967.

Table 5.—U.S. exports of magnesite and magnesia, by countries

Destination	Magnesite and magnesia, dead-burned				Magnesite, n.e.c. including crude, caustic-calcined, lump or ground			
	1967		1968		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	278	$22	293	$27	33	$15	27	$18
Australia	2,908	174	1,802	92	946	236	534	297
Belgium-Luxembourg	80	10	------	------	37	13	92	24
Canada	19,688	2,121	25,506	2,329	1,987	136	1,666	134
Chile	711	55	889	66	26	7	40	9
Colombia	19	4	------	------	133	29	159	44
Costa Rica	200	12	------	------	396	28	331	15
Denmark	------	------	2	1	52	32	28	17
El Salvador	450	27	445	27	------	------	------	------
France	------	------	3	1	188	79	155	66
Germany, West	126	67	102	50	650	386	754	428
Honduras	------	------	------	------	265	31	------	------
India	1	1	------	------	16	7	7	4
Israel	------	------	------	------	10	5	16	10
Italy	31	3	5	1	240	91	286	110
Japan	68	31	30	12	11	5	76	58
Mexico	31,776	2,525	19,092	1,276	684	65	507	51
Netherlands	100	9	20	3	97	38	192	34
New Zealand	------	------	1	1	86	53	151	94
Peru	1,870	127	1,102	70	10	1	1	1
Philippines	3	(1)	1	(1)	62	17	214	42
South Africa, Republic of	88	51	86	59	82	43	113	62
Spain	2	1	------	------	30	15	93	39
Sweden	225	63	39	25	93	51	171	106
Switzerland	------	------	------	------	54	24	45	19
United Kingdom	555	232	367	184	1,018	583	969	518
Venezuela	5,084	334	7,318	471	296	40	290	40
Other	106	20	54	11	286	65	267	71
Total	64,369	5,889	57,157	4,706	7,788	2,095	7,184	2,301

---

[1] Less than ½ unit.

Table 6.—U.S. imports for consumption of crude and processed magnesite, by countries

Country	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Crude magnesite: India	327	$24	--------	--------
Lump or ground caustic-calcined magnesia:				
Australia	1,220	110	1,361	$133
Austria	948	35	1,082	41
Belgium-Luxembourg	--------	--------	110	7
Greece	55	8	1,184	89
India	4,462	278	5,021	319
Laos	56	4	--------	--------
Netherlands	99	7	130	9
New Zealand	50	5	--------	--------
Turkey	1,949	128	2,514	141
Tanzania	--------	--------	55	4
Yugoslavia	330	15	331	15
Total	9,169	585	11,788	758
Dead-burned and grain magnesia and periclase:				
Not containing lime or containing not over 4 percent lime:				
Austria	10,834	612	--------	--------
Canada	116	18	82	12
Germany, West	--------	--------	47	19
Greece	31,254	2,405	64,189	4,778
Italy	822	54	12,316	898
Japan	22,639	1,408	7,554	369
Netherlands	33	11	--------	--------
Turkey	6,938	501	--------	--------
United Kingdom	(1)	2	20	2
Yugoslavia	3,410	165	2,146	101
Total	76,046	5,171	86,354	6,179
Containing over 4 percent lime:				
Austria	25,911	1,040	--------	--------
Canada	830	48	793	42
Italy	577	41	--------	--------
Netherlands	33	11	--------	--------
Yugoslavia	15,062	692	32,705	1,510
Total	42,413	1,832	33,498	1,552
Grand total	118,459	7,003	119,852	7,731

[1] Less than ½ unit.

Table 7.—U.S. imports for consumption of magnesium compounds

Year	Oxide or calcined magnesia		Magnesium carbonate (precipitated)		Magnesium chloride (anhydrous)		Magnesium sulfate (epsom salts and kieserite)		Magnesium salts and compounds n.s.p.f.[1]	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	76	$35	1,090	$213	176	$29	r 55,950	r $651	1,256	$79
1967	64	81	900	173	451	81	r 32,274	r 404	3,354	127
1968	535	183	1,269	222	480	92	44,261	644	2,799	185

r Revised to include kieserite.

[1] Not specifically provided for; includes magnesium silicofluoride or fluosilicate and calcined magnesia.

WORLD REVIEW

Austria.—Hochfilzen Magnesite Mine, in the Austrian Tyrol between Zell and Kitzbül south of Salzburg has been the source of raw magnesite since August 1959 and calcined magnesite since January 1960. Currently, the mine produces 450,000 tons per year of magnesite, the second largest magnesite mine in the world (after Sadka in the Urals), and it accounts for 26 percent of Australian production. It was planned to raise the output to 900,000 to 1,000,000 tons per year and by yearend 1968, most of the needed equipment was already installed.

Canada.—The Aluminum Company of Canada, Ltd., began to phase out operation of its magnesite-lime mine and plant at Wakefield, Quebec. Brucitic limestone has been mined and processed since 1942 to produce magnesium hydroxide and calcined magnesia. The facility has become uneconomical and recently has been operating at a loss.

The Sea Mining Corp., Ltd., plant to produce magnesium hydroxide from sea water and lime was completed at Aquathuna, near Stephenville, on the west coast of Newfoundland. The first shipment of 500,000 pounds of magnesium hydroxide was made to an American firm in December. The Sea Mining Corp., Ltd., is owned by Joseph R. Smallwood and Continental Ore Corp. (recently merged with International Minerals & Chemical Corp.). The Newfoundland Government guaranteed $2.6 million in loans to the corporation. About 20 men are employed. Production will be at the rate of about 100 tons per day of magnesium hydroxide. The principal customers will be paper pulp mills along the St. Lawrence Seaway and the eastern coast of the United States.

Ireland.—The first project in the Republic of Ireland to extract magnesia from seawater and dolomite and convert it into refractory grade magnesia was under con-

Table 8.—World production of magnesite, by countries[1]

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
North America: United States	W	W	W	W	W
South America:					
Brazil	103,331	137,394	140,071	120,430	120,000
Colombia	243	209	[e] 210	[e] 210	NA
Europe:					
Austria	1,826,058	2,001,363	1,779,829	1,692,386	1,704,923
Czechoslovakia	1,858,047	2,029,154	[r] 2,095,221	2,322,331	[e] 2,000,000
Greece	397,054	347,453	413,366	524,476	[e] 550,000
Italy	6,954	3,898	2,867	5,445	----------
Poland	41,888	46,297	[e] 46,000	[e] 46,000	46,000
Spain	102,874	111,944	[e] 110,000	[e] 110,000	110,000
U.S.S.R.[e]	3,090,000	3,200,000	3,200,000	3,300,000	3,300,000
Yugoslavia	548,311	579,750	580,570	468,219	441,272
Africa:					
Kenya	187	74	747	465	NA
Rhodesia, Southern	42,410	39,242	[e] 33,000	NA	NA
South Africa, Republic of	93,443	95,789	102,847	88,199	65,915
Sudan	----------	----------	3,307	3,307	NA
Tanzania	546	1,260	5,270	2,246	NA
Asia:					
China, mainland [e]	1,100,000	1,100,000	1,100,000	880,000	990,000
India	229,210	[r] 264,346	[r] 255,650	270,893	278,264
Iran	6,033	9,259	6,790	[e] 6,600	7,000
Korea, North [e]	990,000	990,000	1,100,000	1,375,000	1,375,000
Pakistan	680	577	812	2,240	[e] 2,200
Turkey	43,065	83,320	[r] 106,934	93,651	129,742
Oceania:					
Australia	35,001	29,525	21,903	26,492	25,000
New Zealand	676	937	624	636	NA
Total [1] [2]	[r] 10,516,001	[r] 11,071,791	[r] 11,106,018	[r] 11,339,226	11,145,316

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Quantities in this table represent crude salable magnesite. Magnesite is also produced in Bulgaria and Canada, but data on production are not available.

[2] Total is of listed figures only.

struction. A $6.5 million installation at Ballynacounty Point, County Waterford, will pump sea water from Dungarvan harbour. The 75,000-ton-per-year plant is owned by Quigley Magnesite, Ltd., subsidiary of Quigley Co., Inc., which itself is a subsidiary of Chas. Pfizer & Co., Inc.

Dolomite will be mined, crushed, and sized at quarries in Bennetsbridge, Kilkenny, and transported to the Waterford plant by rail.

U.S.S.R.—A deposit of crystalline magnesite, claimed to be the world's largest, has been discovered in the Savan Mountains of eastern Siberia. Reserves of 2 billion tons are estimated.

Venezuela.—The Margarita Island magnesite deposits which are reported to contain 5.5 million tons of magnesite came a step closer to production. The Ministry of Mines and Hydrocarbons (MMH), the Venezuelan Development Corp. (CVF), and owners of Loma de Guerra magnesite properties signed a $90,000 contract with Prospection, Ltd., of Canada, whereby the Toronto firm will examine the feasibility of mining the magnesite.

Seawater magnesia plants of the world by country, company, and capacity are listed as follows:

Country	Location	Company	Capacity (short tons MgO)
Canada	Aquathuna, Newfoundland	Sea Mining Corp., Ltd	30,000
Ireland	Dungarvan	Quigley Magnesite, Ltd	75,000
Italy	Sardinia	Steetley Magnesite Co., Ltd	55,000
Mexico	Tampico, Vera Cruz	Quimica del Mar, S.A	50,000
Norway	Heroya	Norsk Hydro-Elektrisk	60,000
United Kingdom	Hartlepool, England	Steetley Magnesite Co., Ltd	250,000
U.S.S.R	NA		100,000
United States	Cape May, N.J	Northwest Magnesite Co	50,000
	Port St. Joe, Fla	Basic, Inc	60,000
	Pascagoula, Miss	H. K. Porter Co., Inc	50,000
	Freeport, Tex	The Dow Dhemical Co	250,000
	Moss Landing, Calif	Kaiser Aluminum & Chemical Corp	150,000
Total			1,180,000

NA Not available.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/18

Manganese

By Gilbert L. DeHuff [1]

Domestic shipments of manganese ore—that is, ore, concentrate, and nodules, containing 35 percent or more manganese—continued to be insignificant compared with consumption. Prices continued soft, and ore imports were somewhat lower than those of the preceding year. Ferromanganese imports remained at approximately the same level. Australia's new Groote Eylandt deposits became a major supplier of manganese ore for both local consumption and export.

Legislation and Government Programs.—In midyear, a contract was awarded for the production of approximately 45,500 short tons of silicomanganese from government-owned manganese ore stockpiled at Johnstown, Pa. Conversion was to be completed by June 15, 1970, with payment to be made in surplus manganese ore from the same stockpile. Deliveries of medium carbon ferromanganese were made to the Government on another upgrading contract, entered into in August 1967, calling for the production of 36,000 short tons of the alloy by June 30, 1971. A revised national stockpile specification, P–109–R1, for silicomanganese was issued April 10, 1968. The range for silicon content was raised to 18.50–21.00 percent from 18.00–20.00 percent, and some changes were made with regard to content of extraneous elements.

No sealed-bid offerings were made by General Services Administration (GSA) for the sale of manganese ore in 1968, but 74,000 short tons of metallurgical ore was sold during the year on a negotiated basis, largely for long-term delivery.

Following application May 24, 1968, under Section 232 of the Trade Expansion Act of 1962 by members of the electric-furnace ferroalloy Industry, the Director of the Office of Emergency Planning (now the Office of Emergency Preparedness) ordered an investigation to determine whether certain ferroalloy imports are damaging to the national security. Standard ferromanganese, medium carbon ferromanganese, and silicomanganese, were among the alloys claimed to be most seriously in need of consideration.

Table 1.—Salient manganese statistics in the United States

(Short tons)

	1964	1965	1966	1967	1968
Manganese ore (35 percent or more Mn):					
Production (shipments):					
Metallurgical	19,126	22,871	W	W	10,536
Battery	6,932	6,387	W	W	842
Total	26,058	29,258	14,406	12,585	11,378
Imports, general	2,064,990	2,575,229	2,553,704	2,058,691	1,827,626
Consumption	2,241,756	2,872,720	2,370,516	2,382,984	2,228,412
Manganiferous ore (5 to 35 percent Mn):					
Production (shipments)	238,776	332,768	324,926	289,160	244,590
Ferromanganese:					
Production	929,486	1,148,011	946,210	940,927	879,962
Exports	3,903	3,273	545	1,861	3,710
Imports for consumption	212,629	257,339	251,972	216,279	207,677
Consumption	1,007,623	1,040,502	1,048,429	982,130	1,016,559

W Withheld to avoid disclosing individual company confidential data.

---

[1] Physical scientist, Division of Mineral Studies.

DOMESTIC PRODUCTION

Taylor-Knapp Co., Philipsburg, Mont., shipped natural battery-grade ore from its stocks, and The Anaconda Company shipped metallurgical oxide nodules made previously from Montana carbonate ore. Goret and Aguilar, Inc., produced manganese ore containing 35 percent or more manganese at the Nancy No. 1 mine in the Luis Lopez district, Socorro County, N.Mex. The ore was concentrated at the firm's mill at Socorro before shipment.

Low-grade manganese ores (ferruginous manganese ores, middlings, and concentrates) containing 10 to 35 percent manganese were shipped from Minnesota, Montana, and New Mexico, and a relatively small quantity of manganiferous iron ore or concentrate containing 5 to 10 percent manganese was shipped from Minnesota. All Minnesota shipments were from the Cuyuna Range. Manganiferous zinc residuum was produced from New Jersey zinc ores.

Discovery was reported of an extensive deposit of small manganese-iron pellets lying in sand off the Michigan and Wisconsin shores of Green Bay, Lake Michigan, at depths of 50 to 100 feet. From analysis of 200 samples, the pellets appeared to have an average manganese content of 9 percent.

Table 2.—Manganese and manganiferous ore shipped[1] in the United States, by States

(Short tons)

Type and State	1967		1968	
	Gross weight	Manganese content	Gross weight	Manganese content
Manganese ore (35 percent or more Mn, natural):				
Montana	12,585	6,084	4,649	2,434
New Mexico			6,729	3,133
Total	12,585	6,084	11,378	5,567
Manganiferous ore:				
Ferruginous manganese ore (10 to 35 percent Mn, natural):				
Colorado	321	64	----------	----------
Minnesota	236,753	34,475	190,058	27,037
Montana	2,763	456	2,063	423
New Mexico	49,323	5,529	50,681	5,504
Total	289,160	40,524	242,802	32,964
Manganiferous iron ore (5 to 10 percent Mn, natural):				
Minnesota	----------	----------	1,788	123
Total manganiferous ore	289,160	40,524	244,590	33,087
Value manganese and manganiferous ore	$2,629,421	----------	$2,407,619	----------

[1] Shipments are used as the measure of manganese production for compiling U.S. mineral production value. They are taken [illegible] considered to be in marketable form for the consumer. Besides direct-shipping ore, they include, without duplication, concentrate and nodules made from domestic ores.

CONSUMPTION, USES, AND STOCKS

In the production of raw steel (ingots, continuous or pressure cast blooms, billets, slabs, etc., and including steel castings), consumption of manganese as ferroalloys, metal, and direct-charged ore per short ton of raw steel produced was 13.6 pounds. Of this total, 11.7 pounds was ferrromanganese; 1.6 pounds, silicomanganese; 0.08 pounds, spiegeleisen; and 0.25 pounds, manganese metal. The comparable 1967 total, on the same basis, is 13.6 pounds with ferromanganese at 11.7, silicomanganese at 1.6, spiegeleisen at 0.05, and metal at 0.25.

Foote Mineral Co. adopted a new organizational structure early in 1968. Its Vancoram Division (formerly Vanadium Corporation of America) was combined with its electrolytic manganese operations to form a new Metallurgical Products Division. The former Keokuk Electro-Metals operation remained apart as its Kemco Division, and other operations of the company were placed in a new Chemicals and Minerals Division.

Electrolytic Manganese and Manganese Metal.—It can be assumed that virtually all the manganese metal consumed, produced, and imported in the United States was electrolytic metal. The new electrolytic manganese plant of Foote Mineral Co. at New Johnsonville, Tenn., went on stream in May and reached capacity in the last quarter of the year. This brought the company's annual metal production capacity close to 25,000 short tons. Foote's two Knoxville, Tenn., plants were closed by a lengthy strike beginning May 1, 1968, and operations were not resumed until December. American Potash & Chemical Corp. (wholly owned subsidiary of Kerr-McGee Corp.) at Hamilton (Aberdeen), Miss., and Union Carbide Corp. at Marietta, Ohio, continued to be the only other domestic producers.

Ferromanganese.—The Lynchburg (Reusens), Va., plant of E. J. Lavino & Co. (International Minerals & Chemical Corp.) remained out of production throughout the year. U.S. shipments of ferromanganese totaled 833,160 short tons compared with 870,781 tons in 1967. The quantity of ferromanganese made in blast furnaces was one and three quarters that made in electric furnaces.

Silicomanganese.—Production of silicomanganese in the United States was 284,000 short tons, compared with 246,000 tons in 1967. Shipments from furnaces were 262,000 tons compared with 240,000 tons in 1967. The ratio of consumption of silicomanganese to consumption of ferromanganese remained at 16 percent.

Spiegeleisen.—The New Jersey Zinc Co. continued to produce spiegeleisen solely by electric furnaces at Palmerton, Pa.

Pig Iron.—In producing pig iron, 537,000 short tons of manganese-bearing ores containing over 5 percent manganese (natural) were consumed. Domestic sources supplied 454,000 tons, of which 314,000 tons were manganiferous iron ore containing 5 to 10 percent manganese, and 140,000 tons were ferruginous manganese ore containing 10 to 35 percent manganese. Foreign sources supplied 83,000 tons, of which 55,000 tons were manganiferous iron ore, 2,000 tons were ferruginous manganese ore, and 26,000 tons contained more than 35 percent manganese.

Battery and Miscellaneous Industries.—The ore reported in table 3 includes that consumed in making synthetic manganese dioxide, but does not include consumption of the synthetic dioxide. American Potash & Chemical Corp. completed expansion of its synthetic (electrolytic) manganese dioxide plant at Henderson, Nev., to a 10,000-short-ton-per-year capacity. Although some synthetic manganese dioxide is used for chemical purposes, most of it is used in the manufacture of dry cell batteries.

The domestic ore and much of the foreign ore used for chemical and miscellaneous purposes did not meet national stockpile specification P–81–R for chemical-grade ore.

Marathon Battery Co., Wausau, Wis., a consumer of manganese ore to produce dry cell batteries, was merged into Gould-

Table 3.—U.S. consumption and stocks of manganese ore[1]

(Short tons)

Use	Consumption 1967	Consumption 1968	Stocks Dec. 31, 1968[2] (including bonded warehouses)
Manganese alloys and metal	2,187,364	2,028,567	1,702,796
Pig iron and steel	43,388	27,167	18,671
Dry cells, chemicals and miscellaneous	152,232	172,678	79,856
Total	2,382,984	2,228,412	[3] 1,801,323

[1] Containing 35 percent or more manganese (natural).
[2] Excluding Government stocks.
[3] Excludes small tonnages of dealers' stocks.

Table 4.—Consumption, by end uses, and stocks of manganese ferroalloys and metal in the United States

(Short tons, gross weight)

Use	Ferromanganese		Silicomanganese	Spiegeleisen	Manganese metal [1]
	High carbon	Medium and low carbon			
1967					
Steel (Ingots and Castings):					
High speed and tool	384	73	17	--------	35
Stainless steel	1,040	2,603	9,791	W	6.554
Alloy (excluding stainless and tool)	130,639	29,141	24,129	3,192	2,782
Carbon steel	602,489	82,053	105,468	12,958	5,608
Other steel	2,202	1,014	848	W	--------
Cast Irons	11,681	1,273	2,592	10,350	36
Welding and hardfacing rods and materials	1,759	340	1,281	--------	1,163
Nonferrous alloys	3,678	204	96	--------	5,708
Miscellaneous and unspecified	97,377	14,180	15,683	2,869	2,157
Total	851,249	130,881	159,905	29,369	24,043
Stocks December 31, 1967 [2]	274,942	34,977	28,870	34,709	5,236
1968					
Steel (Ingots and Castings):					
High speed and tool	337	63	8	--------	33
Stainless steel	1,256	2,339	10,221	W	6,903
Alloy (excluding stainless and tool)	103,578	22,560	30,018	1,687	3,304
Carbon steel	706,892	76,429	107,890	11,428	6,362
Other steel	1,964	W	631	--------	W
Cast Irons	9,944	1,329	2,981	13,920	5
Welding and hardfacing rods and materials	2,031	408	W	--------	1,102
Nonferrous Alloys	4,277	W	49	--------	6,462
Miscellaneous and unspecified	76,949	6,203	12,839	1,073	1,532
Total	907,228	109,331	164,632	28,108	25,703
Stocks December 31, 1968 [2]	283,137	17,752	36,659	38,432	7,103

W Withheld to avoid disclosing individual company confidential data, included in Miscellaneous and unspecified.

[1] Virtually all electrolytic.

[2] Industry stocks held by producers, consumers, and bonded warehouses.

Table 5.—Ferromanganese produced in the United States and metalliferous materials[1] consumed in its manufacture

Year	Ferromanganese produced			Materials consumed		
	Gross weight (short tons)	Manganese content		Manganese ore (35 percent or more Mn natural) [2]		Manganese ore used per ton of ferromanganese [3] made (short tons)
		Percent	Short tons	Foreign (short tons	Domestic (short tons)	
1964	929,486	77.8	722,752	2,082,074	10,371	2.2
1965	1,148,011	77.8	892,725	2,692,290	12,067	2.3
1966	946,210	78.7	744,359	2,183,925	30,043	2.2
1967	940,927	78.2	735,177	2,182,997	4,367	2.3
1968	879,962	78.0	686,370	2,013,360	15,207	2.3

[1] Excluding scrap and other secondary materials.

[2] Includes ore used in producing silicomanganese and metal.

[3] Includes ore used in producing silicomanganese.

National Batteries, Inc., a producer of lead-acid and alkaline batteries. In May, the Marathon division and the Alkaline Battery division, St. Paul, Minn., were combined into one division under the name of Gould Marathon Battery Co.

Howmet Corp. divested itself of its minerals operations, including its plants at Brownsville, Tex., Lynchburg, Va., Camden, N.J., and Conshohocken, Pa. Manganese ores were among the minerals processed. A newly reconstituted Frank Samuel & Co., Inc., with Combustion Engineering Inc. as the majority stockholder, was the buyer. The original Frank Samuel & Co. became a part of Howmet minerals and refractories division in or about 1965.

PRICES

Manganese Ore.—All manganese ore prices are negotiated, being dependent in part on the characteristics and quantity of ore offered, delivery terms, and fluctuating shipping rates. American Metal Market quotations for ore containing 46 to 48 percent manganese dropped 1 cent early in February to 59 to 63 cents, nominal, per long-ton unit, c.i.f. eastern seaboard and gulf ports. This price range continued to be quoted to the end of the year, but the market was notably inactive in the last 2 months, apparently with a weakening in actual prices for the small quantities of ore being sold.

Manganese Alloys.—Standard high-carbon ferromanganese continued to be sold essentially on a "price on request" basis with the actual prices for domestic alloy lying somewhere between $164.50 per long ton and those for imported material, variously quoted from $142 to $157 per long ton, delivered in Pittsburgh or Chicago.

Manganese Metal.—Effective October 21, 1968, the price of standard electrolytic manganese metal in bulk carlots was cut from 29.85 to 26.6 cents per pound, f.o.b. producer's plant. Reductions in other grades of electrolytic metal were made at the same time, and the long-prevailing premium for hydrogen-removed metal was eliminated, resulting in the 26.6-cent price also.

FOREIGN TRADE

Ferromanganese exports totaled 3,710 short tons valued at $645,057, compared with 1,861 tons at $759,955 in 1967. Canada took approximately 75 percent of the quantity in both years. Exports classified as "manganese and manganese alloys, wrought or unwrought, and waste and scrap" were 2,118 tons valued at $1,119,127 in 1968, and 1,388 tons at $857,603 in 1967. Exports of ore and concentrate containing more than 10 percent manganese totaled 18,500 tons at a value of $2,042,305 in 1968, compared with 15,375 tons at $1,502,044 in 1967. These were believed to consist almost entirely of imported manganese dioxide ore exported after grinding, blending, or otherwise classifying.

The average grade of imported manganese ore was 47.5 percent manganese in 1968 compared with 47.3 percent in 1967 and 47.4 percent in 1966. Brazil and Gabon together supplied more than half of the total in 1968. Both general imports and imports for consumption of manganiferous ores containing more than 10 percent, but less than 35 percent, manganese totaled 38,861 short tons in 1968.

Silicomanganese imports for consumption totaled 25,412 short tons containing 16,885 tons of manganese. Sources and tonnage (gross weight) were as follows: Norway, 16,796; Yugoslavia, 6,776; Mexico, 1,556; Canada, 214; and France, 70. General imports, totaling 27,481 tons, showed a similar pattern for origin. Manganese metal imports for consumption were 3,183 tons, compared with 2,237 tons in 1967 and 2,020 tons in 1966. In 1968, the Republic of South Africa supplied 2,797 tons; Japan, 336 tons; and Czechoslovakia, 50 tons. A few pounds of high-unit value were imported from Italy. General imports totaled 3,139 tons and came from the same countries with Japan's contribution somewhat higher and that of the Republic of South Africa lower.

Imports for consumption classified as "manganese compounds, other" totaled 3,059 tons in 1968; 2,106 tons in 1967; and 1,403 tons in 1966. The sources, gross amounts, and values per pound in 1968 were: Japan, 2,393 tons (15.7 cents); United Kingdom, 463 tons (5.9 cents); Belgium-Luxembourg, 161 tons (14.5 cents); and India, 42 tons (3.5 cents). The imports from Japan, and probably those from Belgium-Luxembourg as well, appear to have consisted largely if not entirely of synthetic manganese dioxide.

Table 6.—U.S. imports of manganese ore (35 percent or more Mn), by countries

Country	General imports [1] (short tons)						Imports for consumption [2] (short tons)					
	1967			1968			1967			1968		
	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousands)	Gross weight	Mn content	Value (thousand)
Angola	11,088	5,322	$264	77,017	36,838	$1,839	11,088	5,322	$264	77,017	36,838	$1,839
Australia	---------	---------	---------	76,097	36,634	1,928	---------	---------	---------	76,097	36,634	1,928
Brazil	271,530	128,176	7,278	538,166	254,521	12,718	r 272,191	r 128,454	7,286	538,166	254,521	12,718
British Western Pacific Islands [3]	9,118	4,559	252	---------	---------	---------	9,118	4,559	252	---------	---------	---------
Canada	---------	---------	---------	27	18	2	---------	---------	---------	27	18	2
Chile	3,360	r 1,613	125	---------	---------	---------	3,360	1,613	125	---------	---------	---------
Congo (Kinshasa)[4]	417,849	201,089	10,872	117,695	59,856	3,113	418,178	201,246	10,888	118,602	60,332	3,135
Gabon [5]	r 417,982	r 202,132	10,803	526,227	260,617	14,265	r 419,046	r 202,682	r 10,842	526,227	260,617	14,265
Ghana	r 167,955	r 90,059	7,795	58,871	30,290	1,360	r 167,993	r 90,078	r 7,797	58,871	30,290	1,360
Greece	11,506	5,501	656	---------	---------	---------	11,506	5,501	656	---------	---------	---------
Guyana [6]	95,412	39,479	1,888	108,200	43,246	2,781	95,412	39,479	1,888	108,200	43,246	2,781
India	198,562	90,282	3,971	97,305	47,671	1,861	198,562	90,282	3,971	97,305	47,671	1,861
Iran	1,680	789	36	---------	---------	---------	1,680	789	36	---------	---------	---------
Ivory Coast	80,349	34,898	1,643	45,441	20,562	977	80,349	34,898	1,643	45,441	20,562	977
Japan	---------	---------	---------	17	7	2	---------	---------	---------	17	7	2
Mexico	r 11,308	r 4,885	384	8,124	3,450	276	r 11,365	r 4,909	r 386	8,124	3,450	276
Morocco	61,512	32,053	3,227	32,720	16,789	1,552	61,512	32,053	r 3,227	32,720	16,789	1,552
Mozambique	9,976	5,654	202	---------	---------	---------	9,976	5,654	202	---------	---------	---------
South Africa, Republic of	249,081	108,705	5,067	131,313	54,037	2,334	r 249,481	r 108,867	5,075	133,990	55,096	2,374
Turkey	5,625	2,700	125	6,455	2,657	130	5,625	2,700	125	6,455	2,657	130
Venezuela	---------	---------	---------	2,846	1,110	58	---------	---------	---------	2,846	1,110	58
Western Africa n.e.c. [7]	r 28,080	r 13,391	819	---------	---------	---------	r 28,080	r 13,391	r 819	---------	---------	---------
Western Portuguese Africa n.e.c.	4,480	2,113	130	---------	---------	---------	4,480	2,113	130	---------	---------	---------
Zambia	2,238	1,170	103	1,105	552	56	2,238	1,170	103	1,105	552	56
Total	r 2,058,691	r 974,570	55,640	1,827,626	868,855	45,202	r 2,061,240	r 975,760	r 55,710	1,831,210	870,390	45,264

r Revised.

[1] Comprises ore received in the United States; part went into consumption during the year and the remainder entered bonded warehouses.

[2] Comprises ore received during the year for immediate consumption and ore withdrawn from bonded warehouses.

[3] Probably from New Hebrides, but possibly from Fiji.

[4] Actually imports originating in the Congo (Kinshasa) were approximately 73,000 tons (gross weight) in 1967; see note 5.

[5] In addition: Gabon imports reported as Congo (Kinshasa) were approximately 345,000 tons (gross weight) in 1967; those reported as Western Africa n.e.c. were approximately r 28,000 tons (gross weight) in 1967.

[6] 1967 data adjusted to include ore reported from country of transshipment (Trinidad and Tobago) and also 10,660 tons (gross weight) incorrectly reported as British West Africa; 1968 all reported from Trinidad and Tobago.

[7] Actually from Gabon.

Table 7.—U.S. imports for consumption of ferromanganese, by countries

Country	1967			1968		
	Gross weight (short tons)	Mn content (short (tons)	Value (thousands)	Gross weight (short (tons)	Mn content (short tons)	Value (thousands)
Belgium-Luxembourg	[r] 43,731	[r] 33,346	[r] $4,745	8,905	6,947	$846
Canada	7,824	6,525	2,099	1,166	906	136
Chile	1,159	947	153	356	307	58
France	[r] 37,844	[r] 28,966	[r] 4,343	51,030	39,273	5,232
Gabon	---------	---------	---------	11,216	8,636	527
Germany, West	[r] 22,759	[r] 17,556	[r] 2,566	38,320	29,763	4,331
India	19,023	14,354	2,016	17,244	12,991	1,300
Italy	2,134	1,717	416	1,051	841	208
Japan	6,554	5,332	1,218	904	723	178
Netherlands	---------	---------	---------	3,874	2,874	359
Norway	6,983	5,501	907	2,394	1,888	290
South Africa, Republic of	41,213	32,053	4,294	42,767	33,172	4,102
Spain	3,197	2,402	324	5,747	4,480	646
Sweden	8,268	6,882	1,691	10,493	8,802	2,120
United Kingdom	15,590	12,031	1,665	11,899	8,564	1,010
Yugoslavia	---------	---------	---------	811	527	92
Total	[r] 216,279	[r] 167,612	[r] 26,437	207,677	160,694	21,430

[r] Revised.

WORLD REVIEW

An abundance of good-quality ores from various sources resulted in soft prices for metallurgical ore in all world markets. Strong demand worldwide for dry cells continued to encourage construction of new battery plants. Union Carbide Corp. placed new plants in operation in Ecuador and Greece; was significantly expanding its facilities in Hong Kong, Singapore, and India; formed new companies in Ceylon and Indonesia; brought its Kenya plant to planned output rate; was constructing a plant in Ghana; and was conducting negotiations for plants in Pakistan and the Ivory Coast.

Australia.—Under an agreement with the Australian Government, announced December 3, 1968, by the Minister for the Interior, Broken Hill Proprietary Co. Ltd. (BHP) will establish new and improved beneficiation facilities so that minimum annual capacity at Groote Eylandt will be 700,000 tons of manganese ore by June 1971 and at least 1 million tons 3 years later. As part of the agreement, BHP will conduct research on the agglomeration of fine concentrates, study the feasibility of erecting an agglomerating plant, and will construct such a plant if determined feasible. Five-year reviews by the company of the prospects for ferromanganese production in the Northern Territory or elsewhere in Australia, with construction of a ferromanganese plant if feasible, were additional conditions. On its part, the Government granted new special mineral leases to the company's subsidiary, Groote Eylandt Mining Co.

Congo (Kinshasa).—The manganese mine of Société Minière de Kisenge (SMK) resumed operations in March and had returned to its normal production level by the end of the year. However, the plant of the subsidiary Afropile Battery Co., which had produced flashlight batteries, remained closed because of low prices for dry cells.

Dominican Republic.—The Government granted a concession to Trani Casting Corp., San Gabriel, Calif., for the exploitation of manganese ore in Azua and San Juan Provinces. The company was required to begin roadwork within 30 days and to begin other development work within an additional 180 days.

Guyana.—The Union Carbide Corp. subsidiary, Manganese Mines Management Limited, informed the Government of its intention to stop its manganese mining operations at Matthews Ridge before yearend. The company claimed that it had operated at heavy financial loss for many months because of unfavorable market conditions for this particular type of ore. The

Table 8.—World production of manganese ore, by countries [1]

(Short tons)

Country	Percent Mn •	1964	1965	1966	1967	1968 p
North America:						
Cuba	35–50	77,544	r • 88,000	• 80,000	NA	NA
Mexico [2]	45+	r 156,991	r 144,060	r 76,180	75,444	65,420
United States (shipments)	35+	26,058	29,258	14,406	12,585	11,378
South America:						
Argentina	30−	19,696	9,646	17,639	11,220	4,344
Do	30–40	r 21,385	22,446	r 12,972	• 29,052	29,829
Brazil	38–50	1,490,077	1,538,893	r 1,365,000	1,037,000	1,572,000
Chile	43–47	21,893	18,284	19,754	16,365	25,958
Guyana	36–42	130,907	186,137	201,600	196,820	144,138
Peru	34–45	410	1,091	r 874	1,188	7,885
Europe:						
Bulgaria	30+	57,000	46,000	r 33,000	• 32,000	• 33,000
Greece	50	20,371	11,909	15,981	8,501	• 9,000
Hungary	30−	188,711	234,792	231,485	237,000	230,000
Italy	30−	52,694	52,701	r 48,611	51,917	56,020
Portugal	38–42	7,711	8,559	9,488	10,838	• 10,900
Rumania [2]	35	r 85,000	r 98,900	r 87,850	• 88,000	• 88,000
Spain	30+	17,762	19,247	20,948	9,243	14,248
U.S.S.R. [3]	NA	7,822,000	8,351,000	r 8,493,000	7,909,000	• 8,000,000
Yugoslavia	30+	8,580	8,925	9,498	10,826	NA
Africa:						
Angola	30–52	----------	----------	20,448	36,575	10,086
Botswana	30+	30,639	9,717	----------	----------	4,282
Congo, (Kinshasa)	48+	341,385	416,205	274,809	299,427	354,735
Gabon	50–53	1,057,750	1,411,393	1,403,814	1,264,350	1,283,000
Ghana [4]	48+	509,341	665,821	647,422	549,379	455,617
Ivory Coast	32–47	150,383	198,179	194,212	164,721	128,685
Morocco	35–53	375,974	414,337	399,499	315,413	176,602
Rhodesia, Southern	30+	160	• 230	NA	NA	NA
South Africa, Republic of	30+	1,455,262	1,727,811	1,866,154	2,002,513	2,178,438
South-West Africa	45+	----------	4,185	25,367	• 33,000	• 33,000
Sudan	36–44	• 9,400	1,102	1,653	2,750	5,500
United Arab Republic	35+	• 47,000	• 26,000	• 26,000	NA	4,861
Do	30−	• 314,158	• 174,000	• 178,000	NA	----------
Zambia	35+	40,091	33,965	29,484	27,522	27,962
Asia:						
China, mainland •	30+	1,102,000	1,102,000	1,102,000	770,000	1,000,000
India, including Goa	32–53	r 1,551,824	r 1,815,300	1,849,550	1,752,672	1,766,000
Indonesia	35–49	r 7,467	r 1,328	NA	NA	1,100
Iran	35+	35,300	r 40,310	r 50,000	46,000	• 47,000
Japan	30–43	313,825	333,950	353,733	378,672	356,001
Korea, South	35+	4,753	7,376	6,583	7,982	4,653
Malaysia	30–40	----------	1,754	64,803	93,812	49,787
Pakistan	42+	1,098	560	189	NA	NA
Philippines	30+	8,824	57,038	61,832	95,331	72,800
Thailand	40+	12,185	36,848	77,825	86,603	45,270
Turkey	30–50	22,366	15,675	24,546	• 25,000	27,944
Oceania:						
Australia	35–54	68,442	r 112,414	r 350,045	614,589	826,116
Fiji	40–50	1,004	6,040	5,871	4,883	9,429
New Hebrides	49–55	66,740	78,535	84,040	80,189	• 60,000
Total [5]		r 17,731,661	r 19,556,921	r 19,836,065	r 18,383,377	19,225,000

• Estimate. p Preliminary. r Revised. NA Not available.

[1] Czechoslovakia and Sweden report production of manganese ore (approximately 13 to 17 percent manganese content), but since the manganese content averages substantially less than 30 percent, the output is not included in this table. Czechoslovakia averages annually around 90,000 short tons and Sweden approximately 13,000 tons for the last 5 years.

[2] Estimated from reported content.

[3] Grade unstated. Source: The National Economy of the U.S.S.R., Central Statistical Administration (Moscow).

[4] Dry weight.

[5] Total is of listed figures only.

Government planned to maintain the settlements developed there by converting the region's economy to farming and cattle raising.

India.—The manganese mining industry's continuing problems, accentuated by a buyers' market and closure of the Suez Canal, were under intensive investigation by the Government with cooperation from private manganese producers.

Indonesia.—On May 2, 1968, the Indonesian Government signed an agreement returning to Union Carbide Corp. its wholly owned subsidiary, N.V. National Carbon Co. (Java) Ltd., whose plant for production of dry cells had been expropriated in March 1965. The plant has not produced since January 1967. Company plans call for rehabilitation, modernization, and expansion—in effect an entirely new facility. Some objections apparently were raised, however, by the owners of a dry cell plant at Tjiawi, West Java.

Libya.—After reorganization and with financial help from the Libyan Government, Harati Co. completed its plant built to produce 6 million, size D, 1.5-volt dry cell batteries per year.

Mexico.—The manganese ore mining operations of Cía. Minera Autlán, S.A., at Autlán, Jalisco, closed early in 1968 with the exhaustion of the ore reserves. Key personnel were transferred to the company's new operations in northern Hidalgo, north of Molango and west of the villages of Ixtlahuaca and Tlanchinol, where reserves are estimated to total 11 million tons of carbonate ore averaging 22.5 percent manganese. Of this quantity, 7 million tons are at the underground Acoxcatlán mine in an undulating, manganiferous dolomite bed which rests upon Upper Jurassic shales. The remaining 4 million tons are at the Tezintla open pit at the apex of a sharp fold. The ore is nodulized in a kiln having a capacity to produce 100,000 tons per year of manganese nodules containing 36 percent manganese. The nodules are stated to be self-fluxing and hence equivalent to a normal 45-percent-manganese ore. A trial run of the kiln was made May 8, 1968, but plant capacity was not reached during the year because of unforeseen mining and geological problems. After completion of new dock facilities, most of the product will be trucked 160 miles to Tampico for export to the Bethlehem Steel Co. in the United States. The remainder will be sent to steel plants in the Monterrey area. The nodules produced in 1968 were either stockpiled or shipped to Monterrey steel mills. The entire operation has approximately 900 employees, most of whom live at a well-planned new town at the mine.

Cía. Minera Autlán produced a small tonnage of battery-grade ore on an experimental basis at Nonoalco, south of Molango. This deposit has not been explored, and the company hoped that it could be developed into another unit. Company exploration teams were active throughout Mexico in a search for manganese ore.

South Africa, Republic of.—On February 16, 1968, the issued share capital of Ferroalloys Ltd., wholly owned subsidiary of The Associated Manganese Mines of South Africa Limited, was increased from 2 million to 2.9 million shares, with allotment of the increase to United States Steel Corp. Effective October 1, 1968, the South African Railways and Harbors Administration reduced handling charges on both manganese and iron ore exports through Port Elizabeth. Additional efforts to make South African ore prices more competitive included reduction of overtime costs and the construction of lighter weight railway trucks designed especially to carry ore. Production of electrolytic manganese metal in 1968 by Electrolytic Metal Corp. (Pty.) Ltd., the country's only producer, was 8,785 short tons. Research by the National Institute for Metallurgy investigated, with some promise, the use of manganese dioxide to reduce the sulfur dioxide content of gases emanating from the roasting of refractory gold ores. Besides the antipollution benefits, a manganese sulfate electrolyte is obtained from which electrolytic manganese metal or synthetic manganese dioxide can be produced.

Turkey.—Ore produced in 1967 averaged 40 percent manganese. Mines near Silivri in Thrace and the Cöplerköy mine near Erzincan were the only significant producers. The latter operated as a joint American-Turkish venture. There was little activity in the formerly productive Eregli-Devrek district.

TECHNOLOGY

The Bureau of Mines published the final paper in a series reviewing processes that have been considered as methods for recovering manganese from low-grade or off-grade domestic resources. The paper is concerned with processes based on sulfur dioxide or sulfurous acid leaching, sulfuric acid leaching, combined sulfurous acid-sulfuric acid leaching, and high-temperature sulfatization.[2] The two previous reports reviewed pyrometallurgical, chloride, and fixed nitrogen processes.

A cost evaluation study of a modified Bradley-Fitch ammonium sulfate leaching process for extracting manganese from Cuyuna, Minn., and Aroostook, Maine, manganiferous materials showed that the costs for obtaining manganese by this means would be high. The study was based on an operation scaled to produce 100 tons per day of manganese contained in a synthetic ore suitable for the production of ferromanganese. Briefly, the process consists of the following steps: Reducing the manganese and iron in the ore to MnO and Fe_3O_4 in a shaft furnace; leaching the reduced ore with ammonium sulfate solution to form soluble manganous sulfate, leaving most of the iron undissolved; filtering; precipitating the manganese and some impurities as carbonates; and pelletizing and calcining to form a product consisting mostly of Mn_3O_4. Three raw materials were investigated: Cuyuna black ore containing 10.0 percent manganese and 30.0 percent iron, Cuyuna brown ore containing 6.6 percent manganese and 41.4 percent iron, and Aroostook northern district material containing 10.3 percent manganese and 17.3 percent iron. The Cuyuna black ore, with credit for byproduct iron, showed the best estimated operating costs—$184.81 per ton of contained manganese, which is definitely not competitive with readily available imported manganese ores of good quality. The cost estimates included depreciation based on a straight-line, 10-year period. The study showed, also, that some additional research would be advisable if a commercial-scale operation were contemplated.[3]

Using synthetic acidified ferrous sulfate solutions, optimum autoclaving conditions were established for removing manganese and iron from pregnant liquor that results from leaching Georgia umber with steel-mill pickle liquor. With an oxygen overpressure at 250° to 260° C, precipitation of 98 percent of both the manganese and the iron was achieved with a holding time of approximately 15 minutes. A simple water leach then separated the iron from the manganese by dissolving the ammonium-manganese sulfate to give a relatively pure cell feed at a concentration suitable for use in manganese electrolysis.[4]

As knowledge of the basic magnetic properties for many manganese minerals is sketchy at best, susceptibilities were determined for more than 30 minerals containing manganese.[5] These included isomorphous series showing wide ranges of composition. In order to have clean samples free of extraneous materials, mineral-dressing techniques were used when necessary. Identification of the minerals was established by petrographic and X-ray diffractometer studies.

Transmission electron microscopy at the University of Leeds (England) verified the structure of high damping manganese-copper alloys that are of interest for engineering purposes.[6] Investigation of an alloy containing 70 percent manganese and 30 percent copper that had been aged to peak damping showed a reduction in damping capacity when stored at room temperature or at 100° C. Cold rolling caused a rapid decrease in damping capacity.[7]

Australian practice in the electric furnace production of high-carbon ferromanganese was described.[8]

---

[2] Henn, John J., Ralph C. Kirby, and Lindsay D. Norman, Jr. Review of Major Proposed Processes for Recovering Manganese From United States Resources (in three Parts). 3. Sulfur Oxide Processes. BuMines Inf. Circ. 8368, 1968, 36 pp.

[3] Henn, John J., Frank A. Peters, Paul W. Johnson, and Ralph C. Kirby. An Evaluation of an Ammonium Sulfate Leaching Process for Recovering Manganese From Minnesota and Maine Resources. BuMines Rept. of Inv. 7156, 1968, 68 pp.

[4] Brantley, F. E., E. K. Landis, and W. R. Cureton. Purification and Concentration of a Cyclic Manganese Leach Solution by Elevated Pressure-Temperature Methods. BuMines Rept. of Inv. 7166, 1968, 11 pp.

Brantley, Francis E., and Carl Rampacek (assigned to the U.S. Department of the Interior). Process for Manganese Recovery From Leach Solutions. U.S. Pat. 3,397,130, Aug. 13, 1968.

[5] Powell, H. E., and Lee N. Ballard. Magnetic Susceptibility of 34 Manganese-Bearing Minerals. BuMines Inf. Circ. 8359, 1968, 10 pp.

[6] Butler, E. P., and P. M. Kelly. High Damping Capacity Manganese-Copper Alloys: Part I. Metallography. Trans. AIME, v. 242, No. 10, October 1968, pp. 2099–2106.

[7] Butler, E. P., and P. M. Kelly. High Damping Capacity Manganese-Copper Alloys: Part II. The Effect of Storage and Deformation on the Damping Capacity of 70/30 Mn–Cu Alloy. Trans. AIME, v. 242, No. 10, October 1968, pp. 2107–2109.

[8] Hooper, Rex T. The Production of Ferromanganese. J. Metals, v. 20, No. 5, May 1968, pp. 88–92.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/87

Mercury

By J. M. West [1]

Relatively large releases of mercury from U.S. Government stocks apparently had little effect on mercury prices, which remained above the $500 per flask level throughout 1968.[2] U.S. production increased 21 percent, while imports for consumption declined nearly 5 percent. Overall consumption, based on estimates of mercury dealers, purchasers, and producers, rose 8 percent. Secondary mercury provided a greater share of the total supply (about 46 percent in 1968, compared with 32 percent in 1967) chiefly as a result of increased releases by the General Services Administration (GSA). The scrapping of the last Emmett mercury boiler in the country also contributed to the increased supply of secondary metal. World supplies of new mercury were higher, with significant increases in Spanish, Italian, and Canadian production. Spain and Italy, however, limited exports and apparently were building up stocks at yearend. Prospective, large, new sources of supply included western Canada, Turkey, and Algeria.

Table 1.—Salient mercury statistics

	1964	1965	1966	1967	1968
United States:					
Producing mines	72	149	130	122	87
Production ... flasks	14,142	19,582	22,008	23,784	28,874
Value ... thousands	$4,452	$11,176	$9,722	$11,639	$15,464
Exports ... flasks	188	7,543	357	2,627	7,496
Reexports ... do	196	494	476	475	103
Imports:					
For consumption ... do	41,153	16,238	31,364	24,348	23,246
General ... do	41,107	17,838	34,757	23,899	23,956
Stocks Dec. 31 ... do	17,362	20,386	20,076	18,277	21,484
Consumption ... do	81,354	73,560	71,509	69,517	75,422
Price: New York, average per flask	$314.79	$570.75	$441.72	$489.36	$535.56
World:					
Production ... flasks	255,133	267,873	264,994	232,656	255,474
Price: London, average per flask	$282.25	$607.85	$447.68	$499.36	$546.80

Legislation and Government Programs.—The Government continued to offer financial assistance to mercury miners to the extent of 75 percent of allowable exploration costs through the U.S. Geological Survey's Office of Mineral Exploration. Several applications were in various stages of processing or implementation.

Government stockpile objectives for mercury were unchanged during the year. Releases of stocks originally transferred from the Atomic Energy Commission for disposal continued until only 2,271 excess flasks were left at yearend, and these were scheduled for sale by mid-February 1969. GSA award prices dipped as low as $500 per flask in midyear, after hitting a high on one sale in February of $595.27 per flask. During the year GSA sold 19,610 flasks. In addition, it transferred 4,200 flasks to other agencies, including 2,400 flasks to the U.S. Agency for International Development for its programs. Monthly sales by GSA ranged from 1,050 to 2,500 flasks, with the high in January and February and the low in July.

---

[1] Physical scientist, San Francisco Office of Mineral Resources.

[2] Flask as used throughout this chapter refers to the 76-pound flask.

DOMESTIC PRODUCTION

Prices remained relatively high during the year, encouraging established producers to operate mines and plants at near maximum capacities. Significantly, the number of producers reporting output of over 1,000 flasks increased from four to nine and the number reporting output from 500 to 1,000 flasks decreased from seven to four. Properties producing 100 to 500 flasks increased only from 17 to 18. The total number of producing mines fell sharply to 87, indicating decreased activity among small operators and prospectors.

Of the 87 operations on record in 1968, 53 were in California, 17 in Nevada, six in Oregon, three each in Arizona and Texas, two each in Alaska and Idaho, and one in Washington. California showed the greatest increase in production, largely because of expansion at the New Idria mine and the opening of a new mine, the Last Chance, by El Capitan Mining Co., in the mountains north of the Death Valley area of Inyo County. The Last Chance was discovered by accident several years ago as a result of a sulfur development project and, although it is located in a desolate region, has since become one of the leading producers with potential for expansion.

A breakdown of mercury mining properties follows:

State	County	Mine
PROPERTIES PRODUCING 1,000 FLASKS OR MORE		
California	San Luis Obispo	Buena Vista.
Do	Marin	Gambonini.
Do	Santa Barbara	Gibraltar.
Do	Napa	Knoxville.
Do	Inyo	Last Chance.
Do	Sonoma	Mount Jackson
Do	San Benito	New Idria.
Idaho	Washington	Idaho-Almaden.
Nevada	Humboldt	Cordero.
PROPERTIES PRODUCING 500 TO 1,000 FLASKS		
California	Trinity	Altoona.
Do	Santa Clara	New Almaden.
Nevada	Esmeralda	B & B.
Do	Pershing	Red Bird.
PROPERTIES PRODUCING 100 TO 500 FLASKS		
Alaska	Aniak	White Mountain.
Arizona	Maricopa	National.
California	Lake	Abbott.
Do	Marin	Bueno Chileno.
Do	Napa	Corona.
Do	Sonoma	Culver-Baer.
Do	Santa Clara	Guadalupe.
Do	Lake	Konocti.
Do	Kings	Little King.
Do	San Benito	San Carlos.
Nevada	Pershing	Goldbank.
Do	do	Horton Mercury.
Do	Washoe	Old West.
Oregon	Lane	Black Butte.
Do	Malheur	Bretz.
Do	Lake	Glass Butte.
Texas	Presidio	Fresno.
Do	Brewster	Study Butte.

In 1968 the average grade of domestic mercury ore rose to 5.1 pounds per ton, 1 pound higher than the 1967 average, because a few producers hit relatively rich ore pockets. Byproduct mercury from the Carlin gold mine in Nevada continued to be recovered, but these ores were not counted in average grade calculations. A few flasks of mercury were recovered by reworking mine dumps and from gold placer operations. Secondary mercury production rose by over 50 percent, largely owing to the GSA releases, which are included in this figure. Other sources contributing to the increased production included battery scrap, dental amalgams, and various sludges.

Table 2.—Mercury produced in the United States, by States

Year and State	Producing mines	Flasks	Value [1] (thousands)
1967			
California	78	16,885	$8,018
Idaho	2	898	489
Nevada	25	4,708	2,801
Oregon	6	948	461
Alaska, Arizona, Arkansas, Texas	11	855	420
Total	122	23,784	11,639
1968			
Arizona	8	192	108
California	53	21,417	11,470
Nevada	17	4,780	2,560
Oregon	6	938	502
Alaska, Idaho, Texas, Washington	8	1,547	829
Total	87	28,874	15,464

[1] Value calculated at average New York price.

Table 3.—Mercury ore treated and mercury produced in the United States [1]

Year	Ore treated (short tons)	Mercury produced	
		Flasks	Pounds per ton of ore
1964	149,907	14,115	7.2
1965	339,124	19,353	4.3
1966	321,080	21,993	5.2
1967	439,753	23,767	4.1
1968	432,772	28,857	5.1

[1] Excludes mercury produced from placer operations and from cleanup of furnaces and other plants.

Table 4.—Production of secondary mercury in the United States

Year	Flasks [1]
1964	24,519
1965	46,670
1966	16,400
1967	22,150
1968	34,380

[1] Includes GSA releases.

CONSUMPTION AND USES

Mercury consumption rose by nearly 6,000 flasks in 1968, led by manufacturers of electrical apparatus, particularly mercury battery cells, chlorine and caustic soda, and mildew proofing compounds. These three categories accounted for 60 percent of the total mercury consumed. The startup of new mercury-cell lines in chlorine-caustic soda plants required additional quantities of mercury, which are taken into account separately under the heading of "other uses" in table 5. However, this figure declined in 1968, despite the continued upward trend in mercury-cell installations, indicating that chlorine producers were drawing on their mercury stocks to provide for the additional requirements.

The development of more efficient chlorine cells, requiring less initial and makeup mercury, probably had some effect on consumption, but the projected trends in chlorine production and the industry's preference for mercury over diaphragm cells seemed to assure a steady growth in this use. The U.S. Department of Commerce has estimated an annual 7-percent growth rate in chlorine production through 1974. Reported plans indicate that over 50 percent of this increase in production capacity could be based on the mercury cell, as compared with the present 30 to 35 percent used in chlorine production. According to the statistics of the Chlorine Institute, production of chlorine in 1968 reached nearly 8.5 million short tons, and daily capacity rose by 1,852 tons. Expansions underway were expected to increase daily capacity by at least 2,700 tons by 1970.

It was estimated that the battery industry accounted for roughly 10,000 flasks of the consumption in 1968, and projections pointed to an annual consumption rate exceeding 15,000 flasks by 1974. Little change was projected in mercury usage for laboratory purposes, but a gradual rise was predicted in its use in instruments, which is expected to reach an annual growth of 7 percent by 1974.

Table 5.—Mercury consumed in the United States by uses

(Flasks)

Use	1964	1965	1966	1967	1968
Agriculture (includes fungicides and bactericides for industrial purposes)	3,144	3,116	2,374	3,732	3,430
Amalgamation	308	268	248	219	267
Catalysts	656	924	1,932	2,489	1,914
Dental preparations [1]	2,612	1,619	1,334	1,359	2,089
Electrical apparatus [1]	[r]14,331	[r]16,097	[r]16,257	[r]14,610	17,484
Electrolytic preparation of chlorine and caustic soda	9,572	8,753	11,541	14,306	17,453
General laboratory use:					
Commercial	1,583	1,119	1,563	1,133	1,246
Government	15,746	--------	--------	--------	--------
Industrial and control instruments [1]	4,972	4,628	4,097	3,865	3,935
Paint:					
Antifouling	547	255	140	152	392
Mildew proofing	[r]5,969	[r]8,211	[r]8,280	[r]7,026	10,174
Paper and pulp manufacture	2,148	619	612	446	417
Pharmaceuticals	[r]335	[r]418	[r]232	[r]283	424
Redistilled [2]	11,697	12,131	7,267	7,334	8,252
Other [1] [3]	7,734	15,402	15,632	12,568	7,945
Total	81,354	73,560	71,509	69,517	75,422

[r] Revised.

[1] Does not include redistilled.

[2] A breakdown of the "redistilled" classification showed averages of 44 percent for instruments, 15 percent for dental preparations, 22 percent for electrical apparatus, and 19 percent for all other uses in 1964–67, compared with 49 percent for instruments, 12 percent for dental preparations, 26 percent for electrical apparatus 9 percent for general laboratory and 4 percent for all other uses in 1968.

[3] Includes mercury used for installation and expansion of chlorine caustic soda plants.

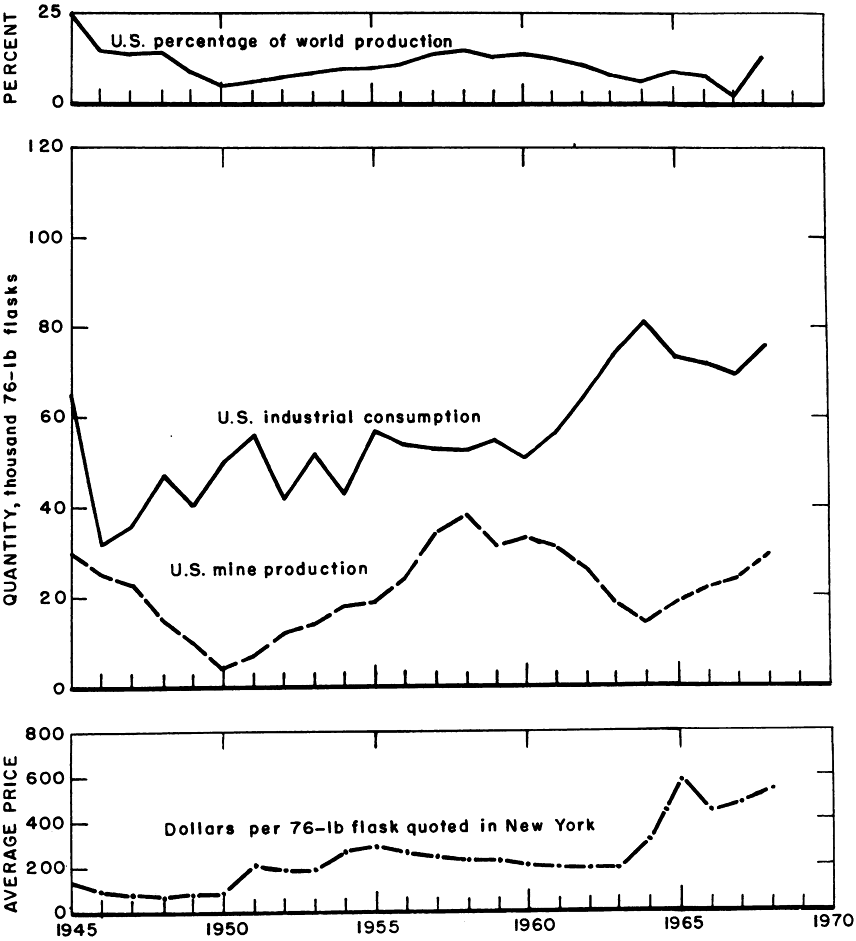

Figure 1.—Trends in production, consumption, and price of mercury.

Table 6.—Stocks of mercury, December 31

(Flasks)

Year	Producer	Consumer and dealer	Total
1964	708	16,654	17,362
1965	1,432	18,954	20,386
1966	1,976	18,100	20,076
1967	r 757	17,520	r 18,277
1968	1,059	20,425	21,484

r Revised.

PRICES

Mercury prices held at relatively high levels during the year, averaging to $535.56 per 76-pound flask on the New York market. This was the second highest yearly average of record, with only 1965 being higher at $570.75, also New York. Monthly price averages ranged from $502.64 to $571.70.

Table 7.—Average monthly prices of mercury at New York and London

(Per flask)

Month	1967		1968	
	New York [1]	London [2]	New York [1]	London [2]
January	485.76	488.43	528.32	536.02
February	503.70	488.97	571.70	597.49
March	506.14	511.72	571.33	587.93
April	488.50	503.85	555.57	566.82
May	452.05	481.07	536.91	561.47
June	480.23	513.02	510.00	524.62
July	475.35	476.63	502.64	518.63
August	483.35	476.29	517.14	523.66
September	497.55	501.07	541.85	540.75
October	488.18	490.54	539.74	545.34
November	498.81	508.41	520.42	532.63
December	512.65	529.39	531.05	526.90
Average	489.36	499.36	535.56	546.80

[1] Metals Week, New York.

[2] Mining Journal (London) prices quoted in pounds sterling were converted to U.S. dollars by using average rates of exchange recorded by Federal Reserve Board.

FOREIGN TRADE

Exports of mercury more than doubled, mainly as a result of increased shipments to India and Japan. Other significant importers, among the approximately 45 countries receiving mercury from the United States, were the United Kingdom and Canada. Indian shipments were in part made in connection with activities of the U.S. Agency for International Development. Reexports from bonded warehouses remained small and went to Hungary and two other countries. Trade in mercury compounds was insignificant.

Imports were chiefly from Spain and from Canada, which became a relatively important source of supply for the first time. Mexico, Peru, and Yugoslavia were also significant sources. Italy, formerly an important U.S. source of supply, provided only a few hundred flasks in 1968. Mercury waste and scrap, largely from Canada, were included in the import figures, and these totaled 576 flasks at an average value of $347 per flask. About 59 short tons of mercury ore, valued at approximately $40,000, was also imported.

The rate of duty on U.S. imports remained $16.72 per flask of mercury during the year, but dropped to $15.20 per flask on January 1, 1969, in accordance with the provisions of the General Agreement on Tariffs and Trade.

Table 8.—U.S. exports and reexports of mercury

Year	Exports		Reexports	
	Flasks	Value (thousands)	Flasks	Value (thousands)
1966	357	$197	476	$280
1967	2,627	1,281	475	193
1968	7,496	3,951	103	54

Table 9.—U.S. imports[1] of mercury, by countries

Country	1966		1967		1968	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Argentina	--------	--------	--------	--------	142	$69
Bolivia	--------	--------	40	$18	20	10
Canada	349	$74	391	97	5,626	2,829
Chile	--------	--------	--------	--------	40	19
France	--------	--------	250	80	--------	--------
Italy	14,485	5,704	5,117	2,308	551	261
Japan	50	26	--------	--------	--------	--------
Mexico	7,049	2,585	1,260	546	2,339	1,076
Netherlands	--------	--------	200	84	--------	--------
Peru	741	271	1,037	427	1,161	463
Philippines	1,150	519	550	238	--------	--------
Spain	7,656	3,272	11,969	5,103	12,900	6,218
Sweden	--------	--------	--------	--------	6	2
United Kingdom	(2)	(2)	--------	--------	--------	--------
Yugoslavia	3,277	1,264	3,085	1,408	1,171	558
Total	34,757	13,715	23,899	10,309	23,956	11,505

[1] Data are "general" imports, that is, they include mercury imported for immediate consumption plus material entering the country under bond.

[2] Less than ½ unit.

Table 10.—U.S. imports for consumption[1] of mercury, by countries

Country	1966		1967		1968	
	Flasks	Value (thousands)	Flasks	Value (thousands)	Flasks	Value (thousands)
Argentina	--------	--------	--------	--------	142	$69
Bolivia	--------	--------	40	$18	20	10
Canada	349	$74	391	97	5,626	2,829
Chile	--------	--------	--------	--------	40	19
France	--------	--------	250	80	--------	--------
Italy	13,942	5,554	4,091	1,831	252	119
Japan	50	26	--------	--------	--------	--------
Mexico	6,030	2,212	1,234	533	1,928	877
Netherlands	--------	--------	200	84	--------	--------
Peru	451	149	1,037	427	1,161	463
Philippines	1,150	519	550	238	--------	--------
Spain	6,115	2,524	13,470	5,837	12,900	6,218
Sweden	--------	--------	--------	--------	6	2
United Kingdom	(2)	(2)	--------	--------	--------	--------
Yugoslavia	3,277	1,264	3,085	[r] 1,408	1,171	558
Total	31,364	12,322	24,348	[r] 10,553	23,246	11,164

[r] Revised.

[1] Data include mercury imported for immediate consumption plus material withdrawn from bonded warehouses.

[2] Less than ½ unit.

WORLD REVIEW

Algeria.—A sizable deposit of mercury was reportedly found in the eastern part of Algeria, and facilities for mining and processing the ores were said to be forthcoming at Ismail. Previously, Algeria was not a significant producer of the metal. The U.S.S.R. was credited with assisting in the discovery.

Canada.—Several new developments in Canada which, when fully operational, will increase Canadian mercury output almost to the U.S. level, were all but ready to begin production. These include the Pinchi Lake mine, belonging to Consolidated Mining & Smelting Co. of Canada, Ltd., and the Lillooet area mine, owned by Silverquick Development Co. Ltd., both located in British Columbia. Late in 1968, Pinchi Lake was reportedly milling about 700 tons (capacity, 800 tons) of low-grade ore per day, processing it by flotation, and then roasting it. The ore occurs in a bed of dolomitized limestone between bands of schist. Silverquick's mine, near Gold Bridge, British Columbia, was expected to come into production by mid-1969, with 3,000 flasks of mercury the output target for the first year, hopefully to be doubled in the second year. Ajax Mercury Mines Ltd. resumed prospecting and bulk sampling at its Sunshine property near Fort St. James, British Columbia.

Table 11.—World production of mercury, by countries

(Flasks)

Country	1964	1965	1966	1967	1968 ᵖ
Bolivia (exports)	[1] 32	52	4	ʳ 145	184
Canada	73	20	---------	---------	ᵉ 5,000
Chile	267	ʳ 435	96	184	513
China, mainland ᵉ	26,000	26,000	26,000	20,000	20,000
Colombia	3	46	ʳ 89	ʳ 210	285
Czechoslovakia	775	825	875	900	900
Italy	57,001	57,320	53,549	48,066	52,215
Japan	ʳ 4,972	ʳ 4,689	4,846	ʳ 4,617	5,049
Mexico	12,561	19,203	ʳ 22,104	ʳ 14,413	ᵉ 13,280
Peru	3,275	3,117	3,166	2,980	3,125
Philippines	2,496	2,384	2,443	2,611	3,506
Rumania	194	191	190	190	ᵉ 203
Spain	78,322	74,661	70,054	49,227	57,262
Tunisia	87	174	254	292	ᵉ 300
Turkey	2,615	2,755	3,420	ʳ 4,147	4,320
U.S.S.R.ᵉ	35,000	40,000	40,000	45,000	45,000
United States	14,142	19,582	22,008	23,784	28,874
Yugoslavia	17,318	16,419	15,896	15,890	ᵉ 15,558
Total [2]	ʳ 255,133	ʳ 267,873	ʳ 264,994	ʳ 232,656	255,474

ᵉ Estimate. ᵖ Preliminary. ʳ Revised. NA Not available.

[1] Purchases by Banco Minero.

[2] Total is of listed figures only.

Ireland.—Ireland was expected to begin production of mercury in small quantities, as a result of the discovery of recoverable amounts in copper concentrates from a newly operating mine. Several mercury minerals were identified in the low-copper, high-arsenic, and antimony sections of the mine. The deposit was estimated to contain close to 15,000 flasks of recoverable mercury. Operated by Gortdrum Mines (Ireland) Ltd., the mine is located in the Silvermines district of northern County Tipperary.

Italy.—Monte Amiata, the leading Italian mercury producer, treated ores from Selvena, Grosseto, and from local mines at its 50,000-flask-per-year distillation plant in Abbadia San Salvatore (Sienna). The grade of ore declined in 1966–67, and there seemed little likelihood of improvement in 1968. Lower grade ore at another important producer's mine, that of Stabilimento Minerario del Siele S.p.A., prompted plans to expand the capacity of crushing and retorting facilities in order to treat larger tonnages. A proposal was submitted to the Italian parliament that would reimpose a manufacturing tax on quicksilver, presumably along the lines of the one canceled in early 1962.

Mexico.—The smuggling of mercury to avoid payment of relatively heavy production taxes and export duties was a subject of official concern. The Mexican Government, determined to reduce these illegal transactions, cut the taxes and duties in half on January 1, 1968, to approximately $40 per flask. It appeared later in the year that total revenues at the reduced rates might even exceed the amounts collected before, indicating the effectiveness of the measure.

Philippines.—Export of Philippine mercury was curtailed to some extent by the expansion of domestic chlorine facilities, which absorbed a notable part of the country's output. All production was in Palawan, where the ore reserves are sizable but the grade is poor.

Table 12.—Italy: Exports of mercury, by countries

(Flasks)

Destination	1967 [1]	1968 [2]
Australia	745	508
Austria	------	15
Belgium-Luxembourg	100	NA
Bulgaria	58	NA
Denmark	90	NA
France	1,303	51
Germany:		
East	2,502	2,883
West	3,706	2,602
Hungary	300	400
Israel	90	NA
India	3,126	1,813
Japan	5,835	6,153
Netherlands	260	45
Poland	658	1,435
Rumania	301	189
South Africa, Republic of	101	31
Sweden	80	NA
Switzerland	52	NA
United Kingdom	8,792	7,133
United States	8,791	2,753
Other countries	41	8,662
Total	36,931	34,673

[1] Final figures. Calculated from quantities reported in kilograms.

[2] Provisional figures. Calculated from quantities reported partly in flasks but mostly in quintals.

Spain.—Operations at the world-famous Almaden mercury mine remained depressed in 1968, although various projects had been started to modernize plant and mining facilities. Recent declines in production were blamed on outdated equipment and extraction methods. Adding to the problem was the failure of the state-owned mercury monopoly, which controls virtually all Spanish production, to respond adequately to stepped-up world demand for the metal. Declines have also been attributed to the policy of withholding mercury from markets in order to keep prices up.

During the first 4 months of 1968, overall Spanish production totaled about 21,500 flasks, compared with 17,000 flasks in the same period of 1967; thus, an upswing appeared likely. The average mercury content of the treated ore was 1.37 percent in early 1968, compared with 1.10 percent in early 1967, indicating a turn toward more selective mining of higher grade ore. Various aspects of mining and processing at Almaden were described in a London publication.[3]

Table 13.—Spain and Yugoslavia: Exports of mercury,[1] by countries

(Flasks)

Destination	From Spain			From Yugoslavia		
	1966	1967	1968 [2]	1966	1967	1968 [3]
Australia	1,092	621	71	--------	--------	NA
Austria	145	--------	--------	53	--------	
Belgium-Luxembourg	529	217	50	--------	--------	
Canada	1,551	951	350	--------	--------	
Czechoslovakia	2,927	2,852	3,603	--------	--------	
Finland	100	300	101	--------	--------	
France	2,328	4,266	1,825	--------	--------	
Germany:						
East	1,201	1,001	1,001	--------	--------	
West	11,822	10,220	7,056	2,375	2,089	
Hungary	1,339	901	400	--------	--------	
India	233	2,252	NA	348	783	
Japan	5,153	4,180	3,733	--------	--------	
Netherlands	2,527	857	270	72	--------	
Poland	1,426	1,401	NA	--------	--------	
Portugal	737	202	74	--------	--------	
Rumania	NA	2,173	400	--------	--------	
South Africa, Republic of	2,806	NA	300	--------	--------	
Sweden	1,431	676	1,551	142	--------	
Switzerland	565	25	10	--------	--------	
United Kingdom	6,675	2,502	1,001	2,301	3,132	
United States	7,856	14,536	9,836	6,115	5,716	
U.S.S.R	NA	NA	NA	2,900	2,900	
Other countries	186	390	121	10	58	
Total	52,629	50,523	[4] 42,973	14,316	14,678	11,661

NA Not available.

[1] Calculated from quantities reported in kilograms.

[2] 9 months only (January–September).

[3] 10 months only (January–October). Breakdown by countries not available.

[4] Total includes 4th quarter (October–December) exports of 11,220 flasks not broken down by country.

---

[3] Mining Magazine. Almaden—World's Largest Mercury Mine. V. 118, No. 2, February 1968, pp. 81–91.

Turkey.—Turkey has long been a small producer of mercury, but successful exploration in recent years indicates that it could produce 20,000 or more flasks per year. In fact, it has been suggested that by 1972 Turkey could be producing 40,000 flasks per year.[4]

Several new retorting plants were under construction or nearing completion. Promising discoveries have been made in the area extending almost 450 miles from the Karaburun Peninsula, near Izmir, to Nigde. Turkey's mercury industry continued to be dominated by one government-owned and two private companies. Higher outputs were expected at nearly every significant mine in 1968–69.[5]

TECHNOLOGY

The U.S. Geological Survey conducted tests from an aircraft, in which air samples were taken at an altitude of 200 feet above ground. Using sophisticated analytical methods, the Survey found that the samples taken over an area of known mercury deposits contained 20 times the background level of mercury. Similar sampling over several copper deposits showed about 10 times the background amounts. In tests at Cortez, Nev., samples of air collected at ground level contained anomalous amounts of mercury, which correlated with the distribution of known gold-bearing rocks, concealed under as much as 100 feet of gravel in places. Near Battle Mountain, Nev., mercury was detected in the air around faults cutting through basalt, in which there had been no previous evidence of mercury. The conclusion from these tests was that air sampling for mercury probably will become an important new exploration tool, not only for mercury but for associated minerals as well.

Technological innovations in a new make of mercury cell will reportedly decrease the amount of needed startup mercury by 40 percent. The mercury requirement for a typical chlorine plant, producing 100 tons per day, will be decreased from 135,000 to 83,600 pounds.[6] This technological development could have a significant effect on the demand for mercury.

Mercury was among a group of metals shown to be separable by a process of selective absorption of metal-chloride vapors using activated carbon.[7] A gaseous mixture of oxygen-free, fully reacted metal chlorides is placed in contact with heated, chlorine-treated, activated carbon at a temperature between 100°C and 700°C, specifically selected above the volatization temperature for metal chlorides to be fractionated. Absorption by the carbon is selective, at least to some extent, depending on the metals present. After reaction, the loaded carbon can be stripped of its mercury or other metal. The effluent fraction is converted to metal by hydrolysis with steam, and the metal is smelted.

---

[4] U.S. Embassy, Ankara, Turkey. Mercury Industry of Turkey—An Updating. Department of State Airgram A–644, June 11, 1968, 18 pp.

[5] Mining Journal (London). Turkey's Expanding Output. V. 271, No. 6943, Sept. 13, 1968, p. 197.

[6] Chemical Engineering. V. 75, No. 2, Jan. 15, 1968, pp. 18–19.

[7] Peterson, H. D., J. L. Drobnick, and S. B. Smith (assigned to West Virginia Pulp & Paper Co.). Method of Separating Metal Chlorides. U.S. Pat. 3,388,993, June 18, 1968.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/191

Mica

By Benjamin Petkof[1]

The sale or use of domestically produced sheet mica has remained below that of the years prior to 1966. Only a small output of sheet mica was noted in 1968. The output of scrap and flake showed a significant increase over that of the previous year. The production of ground mica from scrap and flake remained strong. Imports of uncut sheet and punch declined while imports of scrap increased. All classes of exports showed substantial increases.

Table 1.—Salient mica statistics

	1964	1965	1966	1967	1968
United States:					
Sold or used by producers:					
Sheet mica……thousand pounds..	243	716	4	20	15
Value……thousands..	$58	$185	$1	W	W
Scrap and flake mica……thousand short tons..	115	120	113	119	125
Value……thousands..	$3,353	$3,468	$3,732	$2,876	$3,014
Ground mica……thousand short tons..	116	127	103	97	111
Value……thousands..	$6,902	$7,615	$6,247	$5,756	$7,072
Consumption, block and film……thousand pounds..	2,618	2,659	2,813	1,972	1,628
Value……thousands..	$3,002	$3,188	$3,642	$2,757	$2,591
Consumption, splittings……thousand pounds..	7,608	8,260	7,100	6,188	4,785
Value……thousands..	$3,149	$3,701	$3,221	$2,759	$2,010
Exports……thousand short tons..	5	4	6	7	14
Imports for consumption……do....	8	9	7	[r]4	5
World: Production……thousand pounds..	322,695	345,457	328,411	317,097	337,524

[r] Revised.
W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Sheet Mica.—The output of sheet mica larger than punch and circle declined almost 27 percent from that of the previous year. North Carolina was the only producing State.

Scrap and Flake Mica.—The output of this mica category increased 5 percent in both quantity and value. North Carolina retained its status as the largest scrap and flake producer with 55 percent of total output. The remainder was produced in nine other States.

Ground Mica.—Sales of ground mica again rose above 100,000 short tons and increased 15 percent over that of 1967; value increased 23 percent. The dry grinding process accounted for 87 percent of total output; the remainder was produced by the wet grinding process. Reports were received from 21 grinders operating 18 dry and three wet grinding plants.

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Mica sold or used by producers in the United States

Year and State	Sheet mica						Scrap and flake mica [1]	
	Uncut punch and circle mica		Uncut mica larger than punch and circle		Total sheet mica			
	Pounds	Value	Pounds	Value	Pounds	Value	Short tons	Value (thousands)
1964	220,586	$37,693	22,076	$20,788	242,662	$58,481	114,729	$3,858
1965	670,506	139,844	45,580	45,142	716,086	184,986	120,255	3,468
1966	4,500	905	-------	-------	4,500	905	118,133	3,732
1967	-------	-------	20,500	W	20,500	W	118,503	2,876
1968:								
North Carolina	-------	-------	15,000	W	15,000	W	69,054	1,640
Other States	-------	-------	-------	-------	-------	-------	[2] 56,269	[2] 1,374
Total	-------	-------	15,000	W	15,000	W	125,323	3,014

W Withheld to avoid disclosing individual company confidential data.

[1] Includes finely divided mica recovered from mica and sericite schist, and mica that is a byproduct of feldspar and kaolin beneficiation.

[2] Alabama, Arizona, California, Connecticut, Georgia, New Mexico, Pennsylvania, South Carolina, and South Dakota.

Table 3.—Ground mica sold by producers in the United States by methods of grinding[1]

Year	Dry-ground		Wet-ground		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1964	99,245	$4,397	16,725	$2,505	115,970	$6,902
1965	110,600	5,316	15,997	2,299	126,597	7,615
1966	87,861	4,110	16,089	2,187	103,450	6,247
1967	82,849	3,842	14,204	1,915	97,053	5,756
1968	96,410	4,862	14,979	2,210	111,389	7,072

[1] Domestic and some imported scrap.

CONSUMPTION AND USES

Sheet Mica.—Consumption of sheet mica consisting of block, film, and splittings, declined 21 percent from 8.2 million pounds in 1967 to 6.4 million pounds in 1968.

The electronic, electric, and other industries consumed about 1.6 million pounds of muscovite block and film. About half of this material was used in the manufacture of vacuum tubes. The remainder was used to manufacture capacitors, electrical equipment, gage glass liners, and other items. Of the material consumed 4 percent was classified as Good Stained or better, 45 percent Stained, and 51 percent lower than stained.

Muscovite block and film was used during the year by 18 companies in 10 States. North Carolina with four consuming plants, and New Jersey and New York, with three each, consumed 61 percent of the domestically fabricated block and film mica. The consumption of phlogopite block declined 22 percent.

Total consumption of mica splittings decreased 23 percent from that of 1967. The demand for splittings was met by imports primarily from India and the Malagasy Republic. End items were manufactured from splittings by 12 companies in nine States. Six companies, two in New York, two in Pennsylvania, and one each in New Hampshire and Massachusetts, consumed almost 3.7 million pounds of splittings or about 77 percent of total consumption.

Built-Up Mica.—Built-up mica was prepared by fabricators in various forms primarily for use as an insulating material. Output of built-up mica has been declining since 1965 and declined 20 percent from

Table 4.—Fabrication of muscovite ruby and nonruby block and film mica and phlogopite block mica, by qualities and end-product uses in the United States in 1968

(Pounds)

Variety, form, and quality	Electronic uses				Nonelectronic uses			
	Capacitors	Tubes	Other	Total	Gage glass and diaphragms	Other	Total	Grand total
Muscovite:								
Block:								
Good Stained or better	1,037	6,826	2,405	10,268	5,052	------	5,052	15,320
Stained	43,320	626,607	24,388	694,315	2,447	6,516	8,963	703,278
Lower than Stained [1]	237,732	181,640	75,311	494,683	14,080	285,991	300,071	794,754
Total	282,089	815,073	102,104	1,199,266	21,579	292,507	314,086	1,513,352
Film:								
First quality	5,315	------	------	5,315	-----	------	------	5,315
Second quality	34,069	------	1,000	35,069	-----	------	------	35,069
Other quality	3,300	------	------	3,300	-----	------	------	3,300
Total	42,684	------	1,000	43,684	-----	------	------	43,684
Block and film:								
Good Stained or better [2]	40,421	6,826	3,405	50,652	5,052	------	5,052	55,704
Stained [3]	46,620	626,607	24,388	697,615	2,447	6,516	8,963	706,578
Lower than Stained	237,732	181,640	75,311	494,683	14,080	285,991	300,071	794,754
Total	324,773	815,073	103,104	1,242,950	21,579	292,507	314,086	1,557,036
Phlogopite: Block (all qualities)	------	------	2,889	2,889	-----	67,787	67,787	70,676

[1] Includes punch mica.
[2] Includes first- and second-quality film.
[3] Includes other-quality film.

Table 5.—Fabrication of muscovite ruby and nonruby block and film mica in the United States in 1968 by qualities and grades

(Pounds)

Form, variety, and quality	Grade					
	No. 4 and larger	No. 5	No. 5½	No. 6	Other [1]	Total
Block:						
Ruby:						
Good Stained or better	4,879	938	477	2,761	--------	9,055
Stained	12,046	40,036	53,393	517,619	36,184	659,278
Lower than Stained	38,820	88,211	60,607	344,423	213,373	745,434
Total	55,745	129,185	114,477	864,803	249,557	1,413,767
Nonruby:						
Good Stained or better	1,978	682	225	3,380	--------	6,265
Stained	780	21,100	4,100	16,650	1,370	44,000
Lower than Stained	9,600	18,770	550	3,900	16,500	49,320
Total	12,358	40,552	4,875	23,930	17,870	99,585
Film:						
Ruby:						
First quality	590	525	750	900	--------	2,765
Second quality	18,585	7,910	3,624	3,350	--------	33,469
Other quality	--------	--------	--------	--------	3,300	3,300
Total	19,175	8,435	4,374	4,250	3,300	39,534
Nonruby:						
First quality	--------	--------	1,400	1,150	--------	2,550
Second quality	--------	--------	1,600	--------	--------	1,600
Other quality	--------	--------	--------	--------	--------	--------
Total	--------	--------	3,000	1,150	--------	4,150

[1] Figures for block mica include all smaller than No. 6 grade and "punch" mica.

Table 6.—Consumption and stocks of mica splittings in the United States, by sources

(Thosand pounds and thousand dollars)

	Indian		Malagasy		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
Consumption:						
1964	7,261	$2,949	347	$200	7,608	$3,149
1965	7,948	3,513	312	188	8,260	3,701
1966	6,749	3,005	351	216	7,100	3,221
1967	5,857	2,566	331	193	6,188	2,759
1968	4,579	1,874	206	136	4,785	2,010
Stocks Dec. 31:						
1964	3,523	NA	245	NA	3,768	NA
1965	3,912	NA	210	NA	4,122	NA
1966	3,669	NA	206	NA	3,875	NA
1967	2,737	NA	159	NA	2,896	NA
1968	2,469	NA	149	NA	2,618	NA

NA Not available.

the quantity used in 1967. Segment plate was the form in greatest demand (30 percent), followed closely by tape (29 percent), and molding plate (21 percent).

Reconstituted Mica.—This form of mica was fabricated by the General Electric Co. at Schenectady, N.Y., the Samica Corp. at Rutland, Vt., and the Acim Paper Corp. at New Hyde Park, N.Y., from specially delaminated mica scrap by papermaking techniques.

Table 7.—Built-up mica[1] sold or used in the United States, by products

(Thousand pounds and thousand dollars)

Product	1967		1968	
	Quantity	Value	Quantity	Value
Molding plate	994	$2,940	929	$2,733
Segment plate	1,442	3,039	1,292	2,709
Heater plate	332	1,002	34	71
Flexible (cold)	594	1,270	347	894
Tape	1,740	6,032	1,225	4,270
Other	234	716	435	1,186
Total [2]	5,336	14,999	4,264	11,863

[1] Consists of alternate layers of binder and irregularly arranged and partly overlapped splittings.

[2] Data may not add to totals shown because of independent rounding.

Table 8.—Ground mica sold by producers in the United States, by uses

Use	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Roofing	27,161	$920	28,413	$909
Wallpaper	W	W	1,049	90
Rubber	6,196	676	6,962	779
Paint	22,374	1,976	24,146	2,295
Plastics	903	126	903	125
Welding rods	525	25	738	35
Joint cement	17,068	945	30,953	2,227
Other uses [1]	22,831	1,089	18,225	611
Total [2]	97,053	5,756	111,389	7,072

W Withheld to avoid disclosing individual company confidential data, included with "Other uses."

[1] Includes mica used for molded electric insulation, house insulation, Christmas tree snow, annealing, well drilling, other purposes and uses indicated by symbol W.

[2] Data may not add to totals shown because of independent rounding.

PRICES

Prices quoted for domestic clear sheet mica as reported in the Engineering and Mining Journal ranged from 7 to 12 cents per pound for the smallest size (punch) to $4 to $8 per pound for 6- by 8-inch sheets. Stained or electric mica was quoted 10 to 20 percent lower. Scrap and flake mica was quoted at $30 to $40 per short ton, depending on quality.

Prices of wet and dry ground mica remained unchanged from those of the previous year.

Table 9.—Price of dry- or wet-ground mica in the United States in 1967[1]

	Cents per pound
Dry-ground:	
Paint, 100 mesh	8¼
Plastic, 100 mesh	8¾
Roofing, 20 to 80 mesh	2—8
Wet-ground:[2]	
Biotite	7
Biotite, less than carlots [3]	8
Paint or lacquer, 325 mesh	8
Paint or lacquer, 325 mesh, less than carlots [3]	9
Rubber	8
Rubber, less than carlots [3]	9
Wallpaper	9

[1] In bags at works, carlots, unless otherwise noted.

[2] Freight allowed east of the Mississippi River, ½ cent higher west of the Mississippi River, 1 cent higher west of the Rockies.

[3] Ex-warehouse or freight allowed east of the Mississippi River.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

Total exports of all classes of mica almost doubled but rose only slightly in value. Exports consisted primarily of ground mica.

Imports of scrap mica tripled in both quantity and value over that of 1967. Uncut sheet and punch mica declined 14 percent in quantity and 23 percent in value. Imports of manufactured mica declined slightly in quantity but remained unchanged in value.

Table 10.—U.S. exports of mica and manufactures of mica, 1968 by countries

Destination	Mica, including sheet, waste and scrap and ground		Manufactured	
	Pounds	Value (thousands)	Pounds	Value (thousands)
Angola	1,107,451	$36	--------	--------
Arabia Peninsula States, n.e.c	65,000	6	--------	--------
Argentina	26,400	3	6,254	$21
Australia	271,400	22	11,658	37
Bahamas	1,206	1	11,088	18
Belgium-Luxembourg	163,265	13	1,116	3
Brazil	40,000	3	5,810	16
Canada	7,468,059	431	230,895	670
Chile	78,200	7	6,018	25
Colombia	32,680	2	1,799	6
Dominican Republic	145,000	1	--------	--------
France	552,509	28	9,763	26
Germany, West	289,514	23	17,552	25
Indonesia	166,600	20	688	2
Iran	825,956	47	469	1
Italy	286,606	11	37,822	128
Jamaica	8,751,738	334	13,200	19
Japan	2,393,112	75	8,417	33
Libya	1,102,850	29	--------	--------
Malaysia	84,500	7	50	(1)
Mexico	197,537	15	20,611	74
Netherlands	243,423	13	1,717	18
New Guinea	100,000	8	180	(1)
New Zealand	40,500	2	62	(1)
Nigeria	173,824	16	--------	--------
Panama	38,984	2	106	(1)
Peru	217,590	12	3,817	9
Philippines	130,800	12	1,596	5
Singapore	150,000	11	168	1
South Africa, Republic of	80,000	2	4,934	14
Spain	28,650	1	8,041	33
Sweden	33,000	3	20,996	29
Switzerland	38,500	4	3,032	9
Taiwan	170,121	14	3,062	11
Trinidad and Tobago	166,332	25	207	2
United Kingdom	262,784	93	33,274	83
Venezuela	862,772	46	3,208	10
Other countries	232,458	30	7,409	40
Total	27,014,321	1,408	474,509	1,358

[1] Less than ½ unit.

Table 11.—U.S. exports and imports of mica

(Thousand pounds and thousand dollars)

Year	Exports		Imports for consumption					
	All classes		Uncut sheet and punch		Scrap		Manufactured	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1966	11,348	$2,541	3,247	$3,993	2,642	$71	7,535	$6,670
1967	14,829	2,534	1,733	1,990	1,016	25	5,440	3,373
1968	27,489	2,766	1,491	1,539	3,217	77	5,293	3,373

Table 12.—U.S. imports for consumption of mica by kinds and countries

Year and country	Unmanufactured [1]									
	Waste and scrap				Block mica		Other			
	Phlogopite		Other				Muscovite		Other.	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1966	346,029	$16	2,296,319	$55	2,520,113	$2,858	335,721	$437	391,427	$703
1967	119,920	2	896,177	22	1,141,038	1,320	312,022	364	280,321	305
1968:										
Argentina	------	----	--------	----	--------	-----	------	----	1,543	2
Brazil	------	----	260,005	6	700,387	710	166,187	236	76,070	14
Ceylon	------	----	--------	----	--------	-----	------	----	45	(2)
Hong Kong	------	----	--------	----	--------	-----	------	----	341	6
India	------	----	2,564,091	61	425,625	329	10,930	40	13,369	61
Japan	------	----	--------	----	--------	-----	------	----	50	3
Malagasy Republic	93,069	5	--------	----	--------	-----	110	(2)	49,153	91
Mexico	------	----	120,000	1	--------	-----	------	----	----	----
Mozambique	------	----	--------	----	--------	-----	551	(2)	661	2
Pakistan	------	----	--------	----	--------	-----	------	----	218	4
South Africa, Republic of	------	----	180,000	4	--------	-----	------	----	33,213	11
Southern Africa, n.e.c.	------	----	--------	----	--------	-----	------	----	21	(2)
Tanzania	------	----	--------	----	2,649	2	8,648	22	42	1
United Kingdom	------	----	--------	----	--------	-----	------	----	800	5
Total	93,069	5	3,124,096	72	1,128,661	1,041	186,426	298	175,526	200

Year and country	Manufactured							
	Splittings		Not cut or stamped not over 0.006 inch in thickness		Cut or stamped			
					Not over 0.006 inch in thickness		Over 0.006 inch in thickness	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1966	6,797,895	2,694	291,461	832	139,828	2,687	92,078	255
1967	4,884,508	1,700	111,856	300	66,498	1,049	92,755	167
1968:								
Brazil	390	1	38,939	39	2,374	9	8,177	22
Czechoslovakia	---------	-------	800	5	-------	-------	-------	-------
France	---------	-------	-------	-------	123	3	-------	-------
Germany, West	---------	-------	-------	-------	259	4	2	(2)
India	4,686,989	1,237	39,777	119	86,696	1,211	69,951	98
Indonesia	---------	-------	-------	-------	888	14	-------	-------
Jamaica	---------	-------	18,011	67	-------	-------	-------	-------
Japan	---------	-------	-------	-------	149	3	-------	-------
Leeward and Windward Islands	---------	-------	70	1	1,132	4	-------	-------
Malagasy Republic	155,685	89	220	1	661	3	-------	-------
Mexico	---------	-------	-------	-------	3,501	124	3,508	23
Mozambique	2,425	6	-------	-------	-------	-------	3,280	2
Netherlands	---------	-------	-------	-------	-------	-------	197	13
Rhodesia, Southern	---------	-------	-------	-------	-------	-------	16,765	14
South Africa, Republic of	18,008	6	-------	-------	-------	-------	18,410	21
Taiwan	---------	-------	-------	-------	381	7	67	2
Tanzania	---------	-------	180	1	-------	-------	-------	-------
United Kingdom	---------	-------	-------	-------	2,430	62	32	1
Total	4,808,447	1,339	97,997	233	98,594	1,444	120,389	191

Table 12.—U.S. imports for consumption of mica by kinds and countries—Continued

Year and country	Mica plates and built-up mica		Ground or pulverized		Articles not especially provided for of mica	
	Pounds	Value (thousands)	Pounds	Value (thousands)	Pounds	Value (thousands)
1966	53,205	$87	148,246	$11	13,359	$104
1967	42,172	57	226,501	21	15,185	79
1968:						
Belgium-Luxembourg	11,136	9	-------	----	1,961	4
Canada	6,322	17	-------	----	-------	----
France	----------	----	113,316	12	40	2
Germany, West	27,242	49	-------	----	269	1
India	----------	----	300	1	1,405	11
Italy	----------	----	-------	----	2	(2)
Japan	1,028	1	-------	----	-------	----
Leeward and Windward Islands	----------	----	-------	----	350	1
Netherlands	----------	----	-------	----	143	6
Taiwan	----------	----	-------	----	546	12
United Kingdom	132	1	-------	----	3,323	39
Total	45,860	77	113,616	13	8,039	76

[1] In addition to classes shown, 2,200 pounds ($400) of untrimmed phlogopite from which no piece over 2 by 1 inch may be cut was imported from Brazil.

[2] Less than ½ unit.

WORLD REVIEW

India.—Crude mica production declined 23 percent from 24,308 tons in 1966 to 18,758 tons in 1967; value declined from $2.9 million in 1966 to $2.3 million in 1967. Exports of all mica categories declined in 1967 except for ground mica which increased slightly. Exports to the U.S.S.R. and other Eastern European countries increased from 12 percent of the 1966 total to 19 percent in 1967. Exports of block mica to France, Italy, Japan, the Netherlands, Spain, and Sweden increased while exports to Australia, Austria, Switzerland, Taiwan, the United Kingdom, and the United States decreased.[2] The decline in production and exports has been attributed to the use of substitute materials in consuming countries and the sale of sheet mica from the U.S. stockpile. As a result of these declines as many as 190 mica mines out of a total of 495 that were in operation in the State of Bihar in 1965, were closed.[3]

---

[2] Bureau of Mines. Mineral Trade Notes. V. 65, No. 10, October 1968, p. 25.

[3] Mining Journal (London). Indian Mica in Doldrums. V. 271, No. 6939, Aug. 16, 1968, p. 117.

Table 13.—World production of mica by countries[1]

(Thousand pounds)

Country	1964	1965	1966	1967	1968 p
North America:					
Canada (shipments):					
Block	89	13	r 4	---------	---------
Ground	616	298	r 340	---------	---------
Scrap	494	236	r 201	---------	---------
Mexico	r 670	r 1,204	878	1,949	1,625
United States (sold or used by producers):					
Sheet	243	716	r 4	20	15
Scrap	229,458	240,510	226,268	237,006	250,646
South America:					
Argentina:					
Sheet	315	231	e r 990	p 302	NA
Waste, scrap, etc	1,173	260	e 260	p 1,894	NA
Brazil	3,241	3,089	r 2,244	[2] 2,295	e 2,205
Europe:					
France	646	430	e 440	631	e 551
Norway, including scrap [2]	8,818	6,614	6,610	9,885	e 9,921
Portugal	NA	NA	3,530	3,658	e 3,527
Yugoslavia	26	119	e r 120	260	NA
Africa:					
Malagasy Republic (phlogopite):					
Block	205	201	141	119	172
Splittings	1,299	1,186	1,440	[3] 1,515	[3] 1,825
Mozambique, including scrap	---------	22	NA	220	NA
South Africa, Republic of:					
Sheet	104	2	1	9	20
Scrap	6,764	5,000	r 4,927	10,181	17,456
South-West Africa, Territory of	331	260	55	NA	NA
Tanzania:					
Sheet	211	227	194	201	154
Scrap	324	370	880	278	527
Asia: India [2]:					
Block	4,264	3,179	3,662	3,543	3,816
Splittings	19,378	20,781	14,138	12,185	13,598
Scrap [4]	42,256	58,781	54,901	30,951	31,466
Oceania: Australia: Damourite	1,270	r 1,728	r 1,198	NA	NA
Total [5]	r 322,695	r 345,457	r 323,411	r 317,097	337,524

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Mica is also produced in China (mainland), Rumania, Southern Rhodesia, Sweden, and U.S.S.R., but data on production are not available.

[2] Exports.

[3] Includes splittings 1,068, scrap 452 in 1967; and splittings 1,598, scrap 227 in 1968.

[4] Includes condenser film as follows, in thousands: 1964, 198 pounds; 1965, 176 pounds; 1966, 212 pounds; 1967, 208 pounds; 1968, 192 pounds.

[5] Total is of listed figures only.

TECHNOLOGY

A comprehensive report was published on the fluorine micas and covered nearly all phases of research, development, and commercial application of this material by both government and industry. The report describes the arc-resistance method for the synthesis of fluorine micas that has been adopted by industry for commercial production.[4]

A method was developed to make mica paper having good insulating and electrical properties at high temperature without the use of a binder. Thin mica flakes are treated in aqua regia to remove contaminates and electrified particles that tend to hold the flakes apart. The flakes are washed in distilled water and dried on a screen where they cling together through natural attraction.[5]

---

[4] Shell, Haskiel R., and Kenneth H. Ivey. Fluorine Micas. BuMines Bull. 647, 1969, pp. 291.

[5] Miller, J. L., Jr. and Kenneth H. Ivey (assigned to the U.S. Department of the Interior). Method of Making Paper From Mica Flakes Which Have Been Subjected to Hot Aqua Regia. U.S. Pat. 3,390,045, June 25, 1968.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/44

Molybdenum

By John L. Morning [1]

The year was marked by a plentiful supply of molybdenum despite production losses resulting from labor problems in North America and reduced production in Chile. U.S. output reached a record high, whereas Canadian output was about the same as in 1967. Three mines, two domestic and one Canadian, completed their first full year of operation and helped to offset the production loss.

Industry stocks increased to a high level as consumption failed to maintain the spectacular growth rate of the middle 1960's. A lower level of molybdenum exports contributed to building the industrial inventory.

Table 1.—Salient molybdenum statistics

(Thousand pounds of contained molybdenum and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Concentrate:					
Production	65,605	77,372	90,532	90,097	93,477
Shipments	65,097	77,310	91,670	81,596	93,245
Value	$97,121	$120,801	$144,327	$133,604	$151,000
Consumption	56,409	68,112	75,476	58,967	75,647
Imports for consumption	-------	142	5	1,179	1
Stock, Dec. 31: Mine and plant	4,303	4,208	3,433	9,919	12,208
Primary products:					
Production	55,946	66,616	74,392	54,922	69,675
Shipments	60,403	71,718	78,811	57,231	63,761
Consumption	43,119	48,621	52,324	49,506	49,271
Stocks, Dec. 31: Producers	4,398	3,839	5,945	7,156	18,170
Free world: Production	77,908	98,531	124,988	126,416	125,673

Legislation and Government Programs.—American Metal Climax, Inc. (AMAX), made the final shipment against a government contract to upgrade molybdenum concentrate to Grade B ferromolydbenum. Payment for the upgrading work was made in ferronickel ingot from the Government stockpile. All subobjectives of the molybdenum stockpiling program have now been fulfilled.

Molybdenum excess to stockpile needs and available for sale under government programs totaled nearly 16 million pounds at yearend. During 1968, the stockpile was reduced 2.7 million pounds of molybdenum compared with a reduction of 1.8 million pounds in 1967.

Table 2.—Molybdenum material in government inventories on December 31, 1968

(Thousand pounds molybdenum)

Type	Stockpile objective	National (strategic) stockpile
Concentrate	21,250	34,931
Ferromolybdenum	7,500	7,501
Molybdic oxide	10,000	12,279
Total	[1] 38,750	54,711

[1] Equivalent to 40 million pounds of molybdenum in concentrate.

---

[1] Physical scientist, Division of Mineral Studies.

DOMESTIC PRODUCTION

Molybdenum production increased to a record high of 94 million pounds despite loss of some byproduct production during the first quarter. Of the total output, about 73 percent was produced from primary molybdenum mines and the balance was recovered as a byproduct from copper, tungsten, and uranium operations. Phelps Dodge Corp. closed down its molybdenum circuit at Morenci, Ariz., and no longer is a molybdenum producer.

AMAX announced its molybdenum production rose to a record high of 60 million pounds in 1968. The new Urad mine completed its first full year of operation, while the plant to recover molybdenum from oxide ore at the Climax mine was closed down. The process at the oxide plant, which had a capacity of 3 million pounds annually, was reported to be inherently more costly than regular molybdenum sulfide recovery. Successful operation of the plant provided valuable experience that may be applicable to other oxide ore. The development of the Henderson molybdenum deposit was reportedly on schedule.

Molybdenum production at Questa, N. Mex., by Molybdenum Corporation of America (Molycorp) was reportedly 9.1 million pounds. Production problems during the first 6 months were corrected at midyear and a higher production rate was achieved during the second 6 months. Molycorp announced plans to expand its production to 14 million pounds annually by late 1969. Development of increased ore reserve made the planned expansion possible. Proven and probable ore reserve total 157 million tons grading 0.186 percent molybdenum disulfide.

Molycorp's exploration activities discovered a potential large low-grade molybdenum deposit 6 miles from its present operation. Grade of the deposit was reported to be about the same as the main Questa orebody.

Despite a 3 month loss of production owing to the copper strike, Magma Copper Co. according to its annual report produced 4.6 million pounds of molybdenum sulfide (MoS_2). A 50-percent plant expansion was scheduled to start in 1969 with full production expected early in 1971. During its first full year of recovering molybdenum, Pima Mining Co. produced 1.5 million pounds according to the annual report of Cyprus Mines Corp.

Duval Sierrita Corp. began development work to bring into production its new Sierrita mine adjoining Duval Corp's. Esperanza mine south of Tucson, Ariz. by 1970. Initial plans called for a 60,000-ton-per-day facility which would produce 12 million pounds of molybdenum annually from its copper-molybdenum ore. In December, Duval announced an expansion of the facilities to 72,000 tons, making it the largest single copper-molybdenum plant in North America.

A small copper-molybdenum deposit was discovered near Jackman, Maine, by East Range Co., a Noranda Mines Ltd. subsidiary. Drilling tests indicated about 20 million tons of low-grade material. Spooner Mines and Oil Ltd. planned to drill on 22 claims adjoining to the south.

The Anaconda Company announced provision was being made to recover molybdenum at its Twin Buttes mine when operation begins in 1969. Whittaker Corp. acquired M&R Refractory Metals, Inc., a producer of molybdenum primary products. M&R has manufacturing plants in Winslow, N.J., and the Netherlands. Pennzoil United Inc. became the parent corporation of Duval Corp. following a merger of the United Gas Corporation and the Pennzoil Company.

Table 3.—Production, shipments, and stocks of molybdenum products in the United States

(Thousand pounds of contained molybdenum)

	1967	1968	1967	1968	1967	1968
	Molybdic oxide [1]		Metal powder		Ammonium molybdate	
Received from other producers	3,393	4,497	38	65	218	184
Gross production during year	50,391	68,793	2,326	2,615	1,291	1,835
Used to make other products listed here	12,422	17,289	1,136	625	739	1,279
Net production	37,969	51,504	1,190	1,990	552	556
Shipments:						
Domestic consumers	35,073	39,290	1,537	1,895	561	453
Exports	5,792	8,683	3	2	249	277
Total	40,865	47,972	1,540	1,897	810	730
Producer stocks, Dec. 31	3,211	11,385	347	509	190	210
	Sodium molybdate		Other [2]		Total [3]	
Received from other producers	62	62	35	146	3,746	4,954
Gross production during year	832	989	14,401	14,702	69,241	88,934
Used to make other products listed here	17	25	5	42	14,319	19,259
Net production	815	965	14,396	14,660	54,922	69,675
Shipments:						
Domestic consumers	780	808	12,070	11,016	50,021	53,462
Exports	25	56	1,141	1,282	7,210	10,299
Total	805	864	13,211	12,298	57,231	63,761
Producer stocks, Dec. 31	110	261	3,298	5,805	7,156	18,170

[1] Includes molybdic oxide briquets, molybdic acid, and molybdenum trioxide.

[2] Includes ferromolybdenum, calcium molybdate, phosphomolybdic acid, molybdenum disulfide, pellets, molybdenum pentachloride, and molybdenum hexacarbonyl.

[3] Data may not add to totals shown because of rounding.

CONSUMPTION AND USES

Reported molybdenum consumption was about the same as in 1967. Molybdenum consumption is closely associated with the level of activity of the iron and steel industry, particularly in the production of alloy and stainless steels.

Molybdenum was used in various alloy steels to impart particular properties. From 0.2 to 0.5 percent molybdenum was added to certain high-strength structural steels which are used in fabrication of machinery, buildings, bridges, and pressure vessels. Molybdenum additions of 0.25 to 8 percent were made to ultrahigh strength steels for use in aircraft, missile structural material, and rail and truck transportation equipment. Maraging steels which have been developed in recent years contain 3.25 to 4.80 percent molybdenum.

The second largest end use for molybdenum was in various grades of stainless steel for its contribution to corrosion resistance and high temperature properties. Large volume applications for these stainless steel grades were in chemical processing equipment, automobiles, and stainless flatware.

An important use for molybdenum was in high speed tool steels which contain up to 8.5 percent molybdenum with an average for this grade estimated at 4 percent. Standard tool steel in the high alloy or hot worked grades contain 1.0 to 1.5 percent molybdenum. Molybdenum was used in the foundry industry to increase hardenability and elevated temperature strength of gray, white, malleable, and ductile iron. Molybdenum metal was used in a wide variety of applications in the electrical and electronic industries, in industrial high temperature equipment, and in chemical processing equipment.

Other important uses for molybdenum were chemical and lubrication applications. Molybdenum catalysts are used in many processes, but the largest use was in hydrotreating and hydrocracking processes in the petroleum industry. Purified molybdenum disulfide was utilized as a lubricant, either alone or as an additive to greases.

A minor use for molybdenum was as an addition to fertilizers, which are used in areas where soils are deficient in this trace element. Molybdenum is one of seven micronutrients required for growth and development of plants.

Table 4.—Consumption of molybdenum materials by end uses, in 1968

(Thousand pounds, contained molybdenum)

End uses	Molybdic oxides	Ferro-molybdenum[1]	Ammonium and sodium molybdate	Other molybdenum materials[2]	Total[3]
Steel (ingots and castings)					
High speed and tool	1,998	1,023	--------	157	3,178
Stainless	4,191	1,826	--------	42	6,059
Alloy (excluding stainless)	18,256	1,672	--------	10	19,939
Carbon	2,674	294	--------	--------	2,969
Other steel	67	42	--------	(4)	109
Cast irons	1,324	2,804	W	82	4,210
Cutting and wear resistant materials	62	250	--------	6	317
Welding and hardfacing rods and materials	--------	406	--------	12	418
Nonferrous alloys	750	641	--------	1,151	2,543
Electrical materials	(4)	--------	--------	23	23
Chemical and ceramic uses:					
Catalysts	1,289	--------	503	--------	1,792
Pigments	770	--------	389	12	1,170
Lubricants	2	--------	--------	749	751
Other	80	--------	69	86	235
Miscellaneous and unspecified	2,334	768	--------	2,462	5,564
Total[3]	33,792	9,727	961	4,791	49,271
Stocks at consumer plants Dec. 31	4,608	2,099	83	711	7,501

W Withheld to avoid disclosing individual company confidential data, included in miscellaneous and unspecified.

[1] Includes calcium molybdate.

[2] Includes purified molybdenum disulfide, molybdenite concentrate added direct to steel, molybdenum metal powder and molybdenum metal pellets.

[3] Data may not add to totals shown due to independent rounding.

[4] Less than ½ reporting unit.

STOCKS

As domestic production of molybdenum outpaced demand, the domestic industrial molybdenum inventory increased to the largest quantity on record. During most of the year producer stocks increased monthly, but at yearend large export shipments were made in anticipation of extended labor problems in the shipping industry. In contrast, consumers with an adequate supply assured decreased their inventory of molybdenum by 2.8 million pounds during the year.

PRICES

Published molybdenum prices of January 1967 remained in effect during 1968. Owing to the large supply some discounting of price was reported during the year, especially for molybdenum concentrate from byproduct sources. Prices in effect at yearend for products sold on a per pound molybdenum basis were as follows: Molybdenum concentrate, $1.62; bagged molybdic oxide, $1.82; and ferromolybdenum, $2.11. Pure molybdic oxide was priced at $1.40 per pound.

FOREIGN TRADE

Exports of ferromolybdenum and molybdenum metal powder dropped sharply as total molybdenum exports decreased about 5 percent and value decreased about 9 percent compared with those of 1967. World consumers worked off stocks accumulated as a hedge against a possible short supply situation that failed to materialize. Heavy exports of molybdenum concentrate (including roasted concentrate) during the last 2 months of the year, in anticipation of labor problems in the shipping industry, helped to prevent a larger decrease in exports. Reexports of molybdenum ore and concentrate to Japan totaled 53,175 pounds molybdenum valued at $96,979. Reexports of molybdenum metal powder to Canada totaled 16,400 pounds valued at $22,000.

Imports of molybdenum concentrate and technical oxide are normally small except during periods of short supply. For 1968, molybdenum concentrate imports totaled 1,223 pounds of contained molybdenum valued at $2,000. Imports of material in chief value molybdenum (believed to be mainly technical oxide) totaled 208,095 pounds of molybdenum valued at $337,535. The molybdenum concentrate came from Chile, whereas material in chief value molybdenum came mainly from Canada. No import transaction was reported for ferromolybdenum.

Molybdenum waste and scrap imported from six countries totaled 220,302 pounds of molybdenum valued at $460,196; the Netherlands and West Germany were the principal suppliers. Imports of unwrought molybdenum totaled 1,600 pounds of contained molybdenum valued at $5,835. Eight countries supplied wrought molybdenum products totaling 21,251 pounds gross weight valued at $218,887; Austria and Sweden were the principal suppliers.

Molybdenum chemicals and related products imported included ammonium molybdate, containing 3,695 pounds of molybdenum valued at $9,548; molybdenum compounds, containing 1,353 pounds of molybdenum valued at $10,312; mixtures of inorganic compounds chief value molybdenum, containing 83 pounds of molybdenum valued at $564; and molybdenum orange, 112,037 pounds gross weight valued at $35,716. There were no transactions for calcium, potassium, and sodium molybdates.

At yearend, the second stage of tariff reductions became effective under the 1967 Kennedy Round of Tariff Negotiations.

Table 5.—Molybdenum reported by producers as shipments for exports from the United States

(Thousand pounds of contained molybdenum)

Product	1967	1968
Molybdenite concentrate	22,240	19,790
Molybdic oxide	5,792	8,683
All other primary products	1,418	1,617

Table 6.—U.S. exports of molybdenum ore and concentrates (including roasted concentrates), by countries

(Thousand pounds and thousand dollars)

Destination	1967		1968	
	Molybdenum (content)	Value	Molybdenum (content)	Value
Australia	73	$121	147	$268
Austria	252	621	27	50
Belgium-Luxembourg	1,878	3,382	2,330	4,007
Brazil	17	39	111	111
Canada	3,415	5,312	1,394	1,497
Czechoslovakia	----------	----------	153	232
France	1,526	2,651	1,117	1,840
Germany, West	1,971	3,502	1,989	3,068
India	1	3	57	106
Italy	455	787	2	4
Japan	2,690	4,916	5,088	9,100
Mexico	260	569	192	378
Netherlands	16,287	27,602	14,652	24,671
New Zealand	3	7	2	5
Philippines	21	48	41	79
South Africa, Republic of	20	50	62	116
Spain	1	(1)	1	1
Sweden	582	950	788	1,172
United Kingdom	488	775	719	1,153
Venezuela	55	94	119	190
Other	5	5	15	32
Total	30,000	51,434	29,006	48,070

[1] Less than ½ unit.

Table 7.—U.S. exports of molybdenum products

(Thousand pounds, gross weight, and thousand dollars)

Product and country	1967 Quantity	1967 Value	1968 Quantity	1968 Value
Ferromolybdenum:[1]				
Australia	94	$190	11	$21
Brazil	81	183	108	145
Canada	317	426	285	367
India	292	566	120	189
Japan	72	142	-----	-----
Mexico	47	75	88	128
Netherlands	388	507	120	159
South Africa, Republic of	160	217	55	73
United Kingdom	20	28	-----	-----
Yugoslavia	-----	-----	45	63
Other	62	102	31	49
Total	1,533	2,436	863	1,194
Metal and alloys in crude form and scrap:				
Germany, West	15	13	9	16
Japan	9	19	145	156
Mexico	18	79	-----	-----
United Kingdom	(2)	(2)	128	16
Other	8	20	11	29
Total	50	131	293	217
Wire:				
Brazil	10	107	5	65
Canada	13	313	9	200
Mexico	2	46	3	56
Netherlands	1	22	4	69
Other	8	173	5	161
Total	34	661	26	551
Powder:				
Canada	213	$352	9	$29
Denmark	-----	-----	2	6
Mexico	10	15	10	14
Netherlands	-----	-----	3	6
Sweden	15	54	24	90
Other	3	13	5	25
Total	241	434	53	170
Semifabricated forms, n.e.c.:				
Canada	4	30	5	55
France	4	26	3	23
Germany, West	1	9	3	30
Italy	2	16	2	14
Japan	227	434	84	181
Mexico	14	20	3	19
Netherlands	2	4	3	39
South Africa, Republic of	2	15	5	31
United Kingdom	9	77	2	23
Other	27	71	8	72
Total	292	702	118	487

[1] Ferromolybdenum contains about 60 to 65 percent molybdenum.
[2] Less than ½ unit.

Table 8.—U.S. import duties

Item	Articles	Rate of duty, January 1, 1969[1]
601.33	Molybdenum ore	19 cents per pound on molybdenum content.
603.40	Material in chief value molybdenum	16 cents per pound on molybdenum content plus 4.5 percent ad valorem.
607.40	Ferromolybdenum	Do.
	Molybdenum:	
628.70	Waste and scrap	16.5 percent ad valorem.
628.72	Unwrought	16 cents per pound on molybdenum content plus 4.5 percent ad valorem.
628.74	Wrought	20 percent ad valorem.
	Molybdenum chemicals:	
417.28	Ammonium molybdate	16 cents per pound on molybdenum content plus 4.5 percent ad valorem.
418.26	Calcium molybdate	Do.
419.60	Molybdenum compounds	Do.
420.22	Potassium molybdate	Do.
421.10	Sodium molybdate	Do.
423.88	Mixtures of inorganic compounds, chief value molybdenum	Do.
473.18	Molybdenum orange	8 percent ad valorem.

[1] Not applicable to Communist countries.

WORLD REVIEW

Argentina.—A United Nations Special Fund project, Plan Perforaciones, concentrated on 10 most promising areas of mineralization discovered under the previous project, Plan Cordillerano. Geological and drilling studies indicate copper-molybdenum deposits at Paramillos Norte and Paramillos Sud. The deposits located in the Andean Mountain region may turn out to be a major copper discovery.

Belgium.—A molybdenum roaster facility was scheduled for construction in Langerbrugge, Belgium, by Soc. Anonyme d'Applications de Chimie Industrielle. Noranda Mines Ltd. (Canada) will supply the molybdenum concentrate under a long-term contract.

Canada.—Canada's molybdenum production, as measured by shipments, dropped slightly in 1968, owing to a work stoppage at the largest producing mine. No additional mine capacity was brought into production during the year; however, one byproduct producer was scheduled for initial production in 1969, and several other byproduct producers are on the horizon. It appears that future capacity expansion will come via byproduct producers and plant expansions rather than new primary mines.

Table 9.—Free world production of molybdenum in ores and concentrates by countries[1]

(Thousand pounds molybdenum)

Country	1964	1965	1966	1967	1968 ^{p}
Australia	---------	26	4	---------	---------
Canada[2]	1,225	9,557	^{r} 20,596	^{r} 21,377	20,007
Chile	8,393	8,142	^{r} 10,232	10,752	8,521
Japan	619	611	542	558	^{e} 500
Korea, South	265	448	659	613	423
Mexico	^{r} 196	^{r} 179	^{r} 331	^{r} 322	^{e} 300
Norway	503	527	500	^{r} 605	^{e} 600
Peru	871	1,499	1,484	2,037	1,750
Philippines	231	170	108	^{r} 55	95
United States	65,605	77,372	90,532	^{r} 90,097	93,477
Total	^{r} 77,908	^{r} 98,531	^{r} 124,988	^{r} 126,416	^{e} 125,673

^{e} Estimate. ^{p} Preliminary. ^{r} Revised.

[1] Molybdenum is also produced in Argentina, Bolivia, Nigeria, South-West Africa, and Spain, but production is negligible.

[2] Shipments.

During the first full year of operation British Columbia Molybdenum Ltd. (British Columbia), a wholly owned subsidiary of Kennecott Copper Corp., produced 5.1 million pounds of molybdenum. According to Kennecott's annual report, grade of concentrate produced exceeded expectations, but production costs also were higher than expected. Ore reserves were estimated at over 40 million tons grading 0.23 percent molybdenite.

Brenda Mines Ltd. concluded financing agreements to develop its large low-grade molybdenum copper deposit. The property was scheduled for production in 1969. Noranda Mines Ltd. was joined by the Bank of Nova Scotia and two Japanese concerns, Nippon Mining Co. Ltd. and Mitsui and Co. Ltd. in financing the venture. In addition, Nippon Mining will purchase the copper output of the mine for a 5-year period. Ore reserve was reported at 167 million tons grading 0.19 percent copper and 0.087 percent molybdenite.

Endako Mines Ltd. (N.P.L.) produced 12 million pounds of molybdenum despite being shut down for nearly 4 months owing to labor problems. Reported ore reserve was 210 million tons at a grade of 0.148 percent molybdenite. The area defined for reserve calculation does not delimit the orebody. A second roaster, with an annual capacity of 8 million pounds of molybdenum, was scheduled for completion in 1969. Mining practice at the Endako Mine was described.[2]

---

[2] Laird, A. M. Open Pit Practice at Endako Mine. Pres. at Annual Meeting of AIME, New York, N.Y., Feb. 25–29, 1968, Preprint No. 68–AO 28, 9pp.

Highmont Mining Corp. Ltd. continued its evaluation of a copper-molybdenum deposit in British Columbia. Material from underground drifting was processed through a bulk sampling plant to furnish information for a final feasibility study. Surface drilling was extended to a depth of 500 feet. Ore reserve based on drilling conducted in 1967 was 45 million tons grading 0.30 percent copper and 0.098 molybdenite.

At yearend, a decision was pending on a feasibility report concerning a low-grade copper molybdenum deposit of Lornex Mining Corp. Based on drilling tests, an ore reserve of 293 million tons grading 0.427 percent copper and 0.14 percent molybdenum was reported. Underground exploration indicated that average grade of ore was a conservative estimate.

Molybdenite Corporation of Canada Ltd. (Quebec) rebuilt its concentrator that was destroyed by fire in 1967. Initial operation was scheduled for late 1968 for the expanded 1,200 tons-per-day facility.

Utah Construction & Mining Co. continued to drill a copper-molybdenum deposit on Vancouver Island, British Columbia. At yearend, the concern was expediting a feasibility study. Ore reserve was reported at 120 million tons grading 0.51 percent copper and 0.025 molybdenum.

Chile.—Chilean output of molybdenum decreased to about the 1964 level. Although both The Anaconda Company mines indicated a gain in copper production, molybdenum output at Chuquicamata dropped substantially, whereas production at El Salvador increased 36 percent. A long drought hampered molybdenum production at Kennecott's El Teniente mine. Chilean molybdenum concentrate deliveries for 1968 were as follows: Chile, 24 percent; West Germany, 23 percent; Sweden, 15 percent; Netherlands, 13 percent; United Kingdom, 11 percent; Japan, 9 percent; and France, 5 percent.

Equador.—As part of a large-scale reconnaissance program under a United Nations Special Fund project, geological prospecting of stream sediments in the Chaucha Valley indicated copper-molybdenum anomalies.

India.—Molybdenite deposits were reported to have been discovered in Medak and Karimnagar districts of the south Indian district of Andhra by the Geological Survey of India.

Japan.—The Japan Rare Metals Co., Ltd., was organized in late 1967 by special steel and ferroalloy manufacturers to stabilize the domestic supply of nickel, cobalt, tungsten, and molybdenum by stockpiling these strategic metals. Its first purchase at midyear was about 100 tons of molybdenum oxide to hedge against work stoppages threatened by mineworkers in North America. Following the settlement of a strike at the facilities of Canada's largest producer, and a major supplier of molybdenum to Japan, the molybdenum was released to Japanese consumers.

Both AMAX of the United States and Endako Mining Ltd. of Canada proposed joint ventures with Japanese ferroalloy firms to construct molybdenum concentrate roasting facilities in Japan. The AMAX proposal includes a 50 to 100 percent share of a planned investment of $4 to $4.5 million to treat 9,000 to 10,000 tons of concentrate per year. The Endako proposal indicates interest in a 50-percent share of a $1.5 million investment to treat 4,500 tons of concentrate annually. AMAX would require half of the concentrate treated to be purchased from the parent company, whereas Endako would require all concentrate to be purchased from the parent company.

During the 1968 fiscal year the Japanese Finance Ministry set a duty free quota of 11,230 short tons for molybdenum ore and concentrate. Import duty beyond the quota was at the rate of 12 percent ad valorem.

Panama.—Porphyry copper deposits discovered by a United Nations mineral survey team in the Colon province also contain molybdenum. The discovery was described as very promising, but extensive exploration will be needed for determining commercial exploitation.

Peru.—Cia. Minera Turmalina S.A. in the Department of Piura became a small producer of molybdenum concentrate in 1967. The present facilities have a capacity of 150 tons of concentrate annually.

Southern Peru Copper Corp. produced less molybdenum concentrate during the year than in 1967 despite a higher level of production of ore and copper. Variation in molybdenum production can be expected from year to year as the molybdenite content of the ore ranges from nothing to 0.15 percent.

TECHNOLOGY

Early in 1966 sulfide copper and molybdenite recoveries began to decrease at Kennecott's Chino Mines Division plant at Santa Rita, N. Mex. Laboratory and pilot plant tests indicated slime interference was the main problem.[3] As a result of the study, the mill flowsheet was altered to include tailing sand flotation and placed in operation in June 1968. Increased recoveries of 20,000 pounds of copper and 500 pounds of molybdenite per day were expected.

Research conducted by the Climax Molybdenum Co. on extracting weakly magnetic molybdenum oxide from lean ores indicated that additional development and research must be performed before a high-capacity, high-intensity, wet magnetic separator will be available to the minerals industry. The results of 7,000 hours of operating experience, test equipment, problems, design consideration and estimated cost range for large separators were described.[4]

The Burau of Mines developed a process to extract about 90 percent of the sulfur from molybdenite flotation concentrate by compacting the concentrate with one-quarter of its weight of aluminum powder, heating it at 800° C for 30 minutes, and then allowing the product to react with water. The thermite reduction yields an impure molybdenum alloy plus aluminum sulfide. The latter readily hydrolyzes to yield pure hydrogen sulfide which can be converted to elemental sulfur by the Claus process. At least 95 percent of the molybdenum can be subsequently recovered as 99.95-percent-pure molybdic oxide.[5]

During the past several years the Bureau of Mines has investigated the chemical and galvanic corrosion properties of high-purity refractory metals and some of their alloys. In 1968 the Bureau found the chemical and galvanic corrosion behavior of the titanium-zirconium-molybdenum (TZM) and molybdenum-30 percent tungsten alloys to be generally equal or superior to that of unalloyed molybdenum in many aqueous solutions of acids, bases, and salts.[6]

---

[3] Rousseau, Edwin S. Tailing Sand Flotation Pilot Plant at Chino. Min. Cong. J., v. 54, No. 9, September 1968, pp. 52–56.

[4] Masoner, T. E. High Intensity Wet Magnetic Separation Research at Climax. Pres. at Annual Meeting of AIME, New York, N.Y. Feb. 25–29, 1968, Preprint 68–B–327, 51 pp.

[5] Haver, F. P., K. Uchida, and M. M. Wong. Recovery of Sulfur From Molybdenite. BuMines Rept. of Inv. 7185, 1968, 15 pp.

[6] Acherman, W. L., J. P. Carter, and David Schlain. Corrosion Properties of the TZM and Molybdenum –30 Tungsten Alloys. BuMines Rept. of Inv. 7169, 1968, 23 pp.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/192

Natural Gas

By William B. Harper [1] and Leonard L. Fanelli [2]

The marketed production of natural gas in 1968 totaled 19,322 billion cubic feet. Production for the year was up 1,151 billion cubic feet above 1967 levels, and Louisiana accounted for almost 61 percent of this increase. Production declines, however, were reported for 15 of the 30 producing States. Primarily due to increased offshore production, Louisiana now accounts for 33.2 percent of total U.S. production compared with 31.5 percent in 1967, while Texas' share declined from 39.6 percent in 1967 to 38.8 percent in 1968. The wellhead price of gas increased 0.4 cents to an average of 16.4 cents per thousand cubic feet (Mcf), exceeding the high of 1967, as shown in table 1.

There were 204 fewer gas wells completed in 1968; the average depth per well increased from 5,898 feet in 1967 to 5,996 feet in 1968. Gas wells in operation were 1,349 fewer in number at the 1968 yearend totaling 110,972 compared with 112,321 on December 31, 1967.

Industrial consumption including use by utilities continued to dominate gas demand. Most industrial usage occurs in Texas and Louisiana where gas holds a strong competitive margin because of its proximity to large industrial complexes. Interstate shipments of domestically produced gas in the Southwest were beginning to decline because more of this gas is being consumed internally, particularly for petrochemicals. Total consumption for the year increased 7.1 percent, and industrial use, the largest segment, was 791 billion cubic feet higher than in 1967. Intrastate gas usage has the added attraction of a shorter reserve life requirements (15 instead of 20 years) than interstate gas, and the time interval between contract negotiations and gas delivery is far shorter. These advantages tend to offset the narrowing price gap between the two gas supplies. The best prospects for interstate gas development appear to be in

Table 1.—Salient statistics of natural gas in the United States

	1964	1965	1966	1967	1968
Supply:					
Marketed production [1] million cubic feet	15,462,143	16,039,753	17,206,628	18,171,325	19,322,400
Withdrawn from storage do	880,498	959,865	1,141,614	1,132,534	1,329,536
Imports do	440,918	456,394	479,780	564,226	651,885
Total do	16,783,559	17,456,012	18,828,022	19,868,085	21,303,821
Disposition:					
Consumption do	15,451,979	16,033,189	17,191,711	18,172,894	19,459,939
Exports do	19,497	26,132	24,639	81,614	93,745
Stored do	1,009,302	1,077,980	1,210,469	1,317,363	1,425,075
Lost in transmission, etc. do	302,781	318,711	401,203	296,214	325,062
Total do	16,783,559	17,456,012	18,828,022	19,868,085	21,303,821
Value at wellhead:					
Total thousand dollars	2,387,689	2,494,542	2,702,759	2,898,741	,168,688
Average cents per Mcf	15.4	15.6	15.7	16.0	16.4

[1] Comprises gas sold or consumed by producers, including gas loss due to natural gas liquids recovery, losses in transmission, quantities added to storage, and increases of gas in pipelines.

---

[1] Mineral specialist, Division of Mineral Studies.
[2] Survey statistician, Division of Statistics.

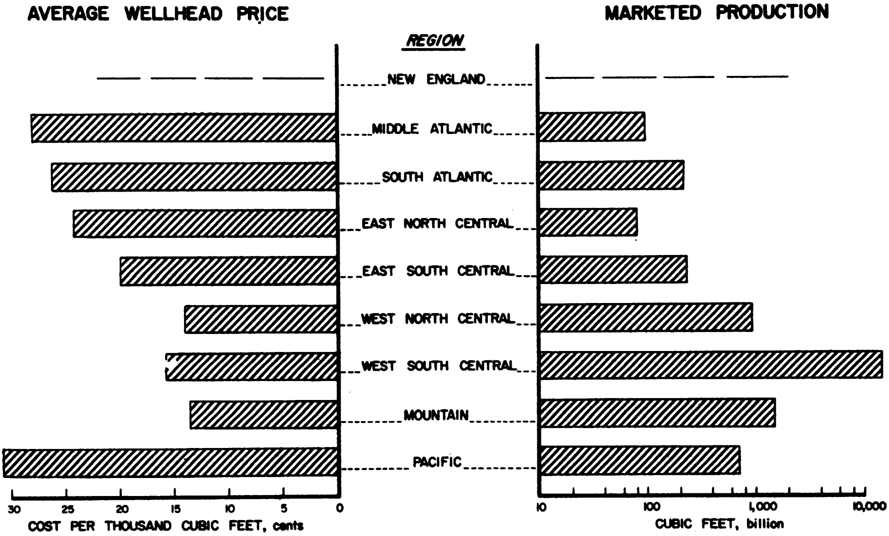

Figure 1.—Marketed production of natural gas by regions and average wellhead prices.

gas from the Outer Continental Shelf of the Gulf of Mexico and, over the longer term, Alaska.

There was 16.3 trillion cubic feet of gas processed at plants in 1968, and from this, 550.3 million barrels of natural gas liquids and ethane was recovered. After a processing loss of 827.9 billion cubic feet, some 13.6 trillion cubic feet was shipped to transmission companies or delivered directly to consumers as indicated in table 7.

According to the American Gas Association (AGA), there were 861,000 miles of gas pipelines at the end of 1968. This includes 234,000 miles of main transmission lines, 64,000 miles of gathering lines, and 563,000 miles of distribution lines. Compared with 1967 figures, main transmission lines increased 8,640 miles, gathering lines 290 miles, and distribution lines 23,800 miles for an overall increase of 32,730 miles.

In this chapter, gas volumes are reported or converted to a pressure base of 14.73 pounds per square inch absolute (psia) at 60° F instead of base of 14.65 psia used previously. This change was adopted in response to the Bureau of the Budget's request to establish uniformity in reporting between Federal and industry gas statistics.

Data on natural gas production, consumption, and value are collected by annual surveys of oil and gas producers, natural gasoline plant operators, gas pipeline companies, and gas utility companies, with separate reports obtained for each State in which they operate.

These reports reflect approximately 80 percent of gross natural gas production. The large number of respondents and the difficulty of canvassing each small producer has made direct acquisition of total production impractical. Most of the output of nonreporting producers has been shown in purchase listings of reporting companies. Marketed production for each State equals consumption in the State, plus losses in transmission, gas placed in storage, and shipment from storage and receipts from other States.

Legislation and Government Programs.—Subsequent to the Supreme Court decision on May 1, 1968, upholding Federal Power Commission Opinion 468 in the Permian Basin Area Rate Processing (AR61-1) fixing gas producer rates for interestate sale for resale, the Federal Power Commission issued Opinion 546 on September 25, 1968, in the South Louisiana Area Rate Proceeding (AR61-2 et al.). This decision conforms to the basic regulatory approach adopted for the Permian Basin area. Shown below are the three price systems for South Louisiana sales:

	Cents at 15.025 psia	
	Onshore and offshore subject to State tax	Federal domain offshore
Gas well gas under contracts dated prior to 1-1-61, *and* all other gas regardless of contract date	18.5	17.0
Gas well gas (and residue therefrom) under contracts dated between 1-1-61 and 9-30-68	19.5	18.0
Gas well gas (and residue therefrom) under contracts dated 10-1-68 and later	20.0	18.5

Contracts dated October 1, 1968, and later are known as "third vintage" gas and as in the Permian case, the Federal Power Commission directed refunds of all amounts subject to the proceedings collected in excess of the applicable ceilings.

Meanwhile, concern has been growing about the near-term availability of natural gas. The President of the American Gas Association wrote to the Chairman of the Federal Power Commission (FPC) on December 16, 1968, expressing concern over the supply situation and urged the Commission to reappraise its regulatory principals and methods.

Subsequently, the FPC asked all interested parties to comment on whether a gas supply investigation for offshore Louisiana should be opened. Although the Commission has not yet opened a broad supply investigation, it did modify some of the area rates for South Louisiana and at the same time instituted a new offshore Louisiana area rate proceeding, (AR69–1), to determine the need for raising the 18.5 ceiling for "third vintage" gas FPC Opinion 546 (gas well gas under contracts dated 10–1–68 and later).

Pipeline Safety.—On August 13, 1968, President Johnson signed the Natural Gas Pipeline Safety Act of 1968. The Act (P.L. 90–481) provides, among other things, that the Secretary of Transportation, within 2 years, established minimum Federal safety standards applicable to the design, installation, inspection, testing, construction, extension, operation, replacement, and maintenance of pipeline facilities used in the transportation of natural gas. Standards affecting the design, installation, construction, initial inspection, and initial testing will not be applicable to pipeline facilities in existence on the date such standards are adopted. Whenever the Secretary finds a particular facility to be hazardous to life or property, he is empowered to require the person operating that facility to take such steps as necessary to remove the hazards. Upon application, the Secretary may waive in whole or in part compliance with any safety standard established under the Act if he determines that such waiver "is not inconsistent with gas pipeline safety." Any State agency may adopt additional or more stringent standards for facilities not subject to FPC jurisdiction as are not incompatible with the Federal minimum standards.

The Act exempts gathering lines in rural areas (but not in populated areas); requires annual certification by the appropriate State agency as to adoption and enforcement of the Federal standards; and provides for civil penalties of $1,000 per day minimum fine and $200,000 maximum for a related series of violations.

CONSUMPTION

A total of nearly 19.5 trillion cubic feet of natural gas was consumed in the United States during 1968. This was an increase of 1,287 billion cubic feet, or 7.1 percent, above the volume consumed in 1967.

In terms of total consumption residential and commercial uses absorbed 32 percent in 1968; oil fields, natural gas processing plants, pipeline fuel and refinery fuel accounted for nearly 18.6 percent; of the 19.5 trillion cubic feet used. Electric utilities burned 16 percent; and other industrial uses made up the remaining 33.4 percent. Of the 12.9 trillion cubic feet for industrial purposes, nearly one-half of the volume was consumed in the West South Central States of Arkansas, Louisiana, Oklahoma, and Texas. Texas produced more gas than any other State but used an amount equal to 55.4 percent of the volume produced within its borders. Louisiana's consumption of about 1,661.8 billion cubic feet was equal to 26 percent of the 6.4 trillion cubic feet produced in the State.

Reflecting the continued growth in demand for natural gas, the U.S. gas industry spent $2,972 million for new plants and equipment in 1968. Included were $1,577 million for new transmission facilities, $913 million for outlays related to distribution, $259 million for production and regular storage, $88 million for underground storage facilities, and other general expenditures totaling $135 million.

Industrial Uses.—In the industrial use category, electric power utilities in the West South Central region used 1.3 trillion cubic feet of natural gas for steam generation, and this accounted for 42.6 percent of the 3.1 trillion cubic feet used for this purpose in the entire United States as indicated in table 5. This is readily understandable, because no other fuel can compete in price with natural gas in the South-

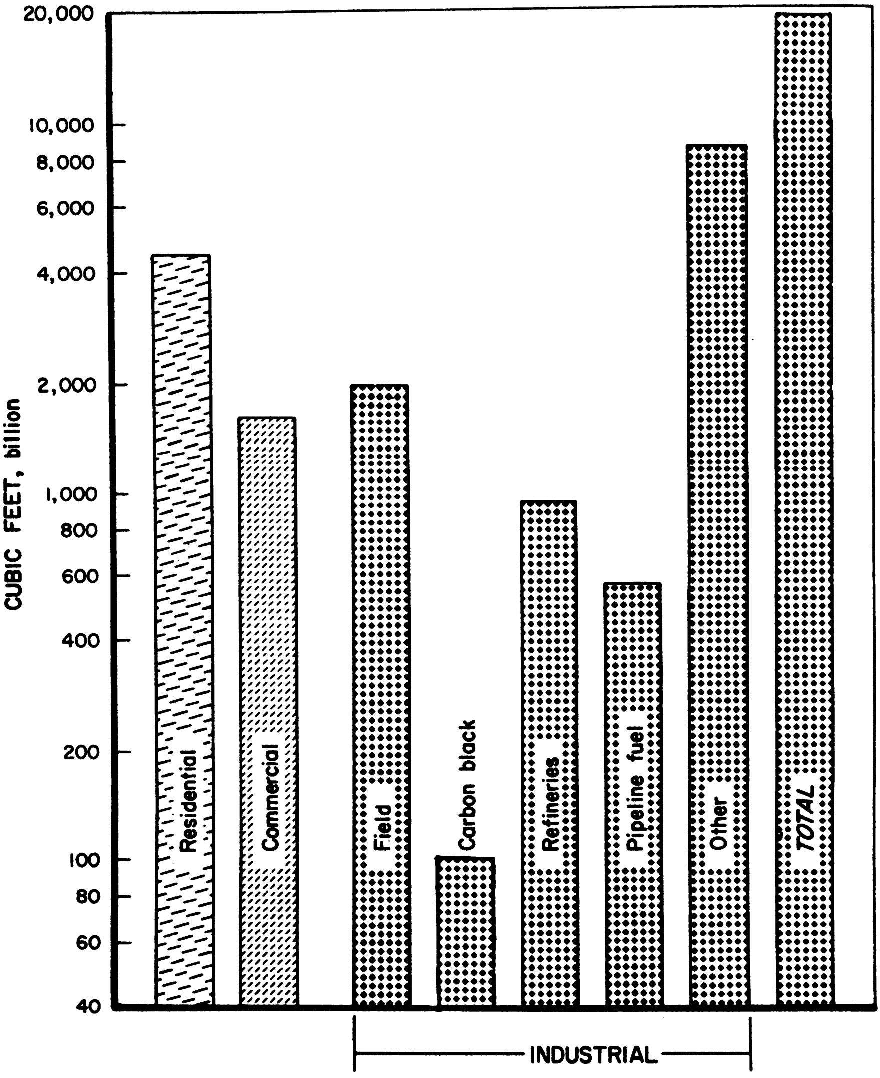

Figure 2.—Disposition of natural gas consumed in the United States by principal use.

west. Natural gas was also used extensively in California for steam generation. However, in this instance, air pollution controls and other restrictions on fuel use in California preclude the likelihood of any noticeable competition from residual fuel oil.

Industrially natural gas was used extensively in the chemical and allied product industries, including carbon black; the metals industry; the building materials industry; the glass industry; foods; and paper and its allied products. Second in importance in terms of consumption was that gas used at natural gas processing plants; in the field for steam generation of electric power for drilling and pumping; as fuel in petroleum refineries and for use as pipeline fuel in pumping stations. The combined petroleum-related uses in 1968, added to 3.6 trillion cubic feet or 28 percent of the entire industrial use of 12.9 trillion including utilities in the United States.

Residential and Commercial Uses.—The number of residential and commercial gas consumers increased to 40.4 million at the end of 1968. Included in this category are consumers who solely or partially use gas for such applications as cooking, water heating, air conditioning, and house heating. There was an increase of 869,000 in the consumer total in 1968, with a gain of 825,000 in residential accounts and 44,000 new commercial users. This increase was smaller than the indicated gain in house-heating accounts reported by the American Gas Association (AGA) for 1968, which suggests that for applications other than house-heating, competitive fuels have made some inroads into the overall gas consumer demand.

Results of the AGA Heating Survey showed a net increase of 1,048,000 in customers who installed gas heating in 1968, bringing the total number of gas individual house-heating customers to over 29.8 million, a gain of 3.4 percent over the 1968 figure. New homes accounted for 669,000 or 63.8 percent of this increase; conversion from other fuels in existing dwellings represented 36.2 percent. In addition to these, 2,967,000 dwelling units in multi-family structures received gas heat from a central or master metered source, bringing the total number of families served by gas heating to 32,770,000, a gain of 3.5 percent over the 1967 figure.

The East North Central region leads the Nation in house-heating customers and the Pacific region ranks second. The AGA forecasts that in the 3 year period ending in 1970, 3.0 million additional heating customers will be recorded.

RESERVES

The Committee of Natural Gas Reserves of the AGA estimated that the total proved recoverable reserves of natural gas in the United States as of December 31, 1968, as shown in table 8, were 287.3 trillion cubic feet, 5,557.8 billion cubic feet less than that a year earlier. This includes estimates of offshore reserves, but separate figures are shown only for the Gulf of Mexico (35.9 trillion cubic feet). At the end of 1967, proved natural gas reserves were 292.9 trillion cubic feet. During 1968, some 7.8 trillion cubic feet were added to reserve estimates based on extensions of known fields. Another 3 trillion were added which were based on revisions of previous estimates. New fields discovered accounted another 1.4 trillion cubic feet and 1.5 trillion were from new reservoir estimates. All of which aggregated about 13.7 trillion cubic feet. During 1968, however, natural gas production topped 19 trillion; hence, the drop in proved reserves of natural gas of nearly 5.6 trillion cubic feet.

The number of gas well completions continued to decline, dropping from 3,659 in 1967 to 3,455 in 1968. The ratio of reserves to annual production as estimated by the Bureau of Mines declined from 16.1 in 1967 to 14.9 in 1968.

The Potential Gas Committee of the Potential Gas Agency[3] released a report estimating potential U.S. gas supply at 1,227 trillion cubic feet as of 12–13–68. This figure is nearly double the 690 trillion cubic feet of potential supply estimated by the Committee two years ago. The potential supply does not include proved recoverable reserves of 287 trillion cubic feet discussed above.

The Potential Gas Committee explained that the current estimate was nearly twice the 1966 estimate for two reasons—inclusion of Alaskan supply (which comprises

---

[3] The Potential Gas Agency, a branch of the Mineral Resource Institute of the Colorado School of Mines, is financed by the American Gas Association, American Petroleum Institute and the Independent Natural Gas Association of America.

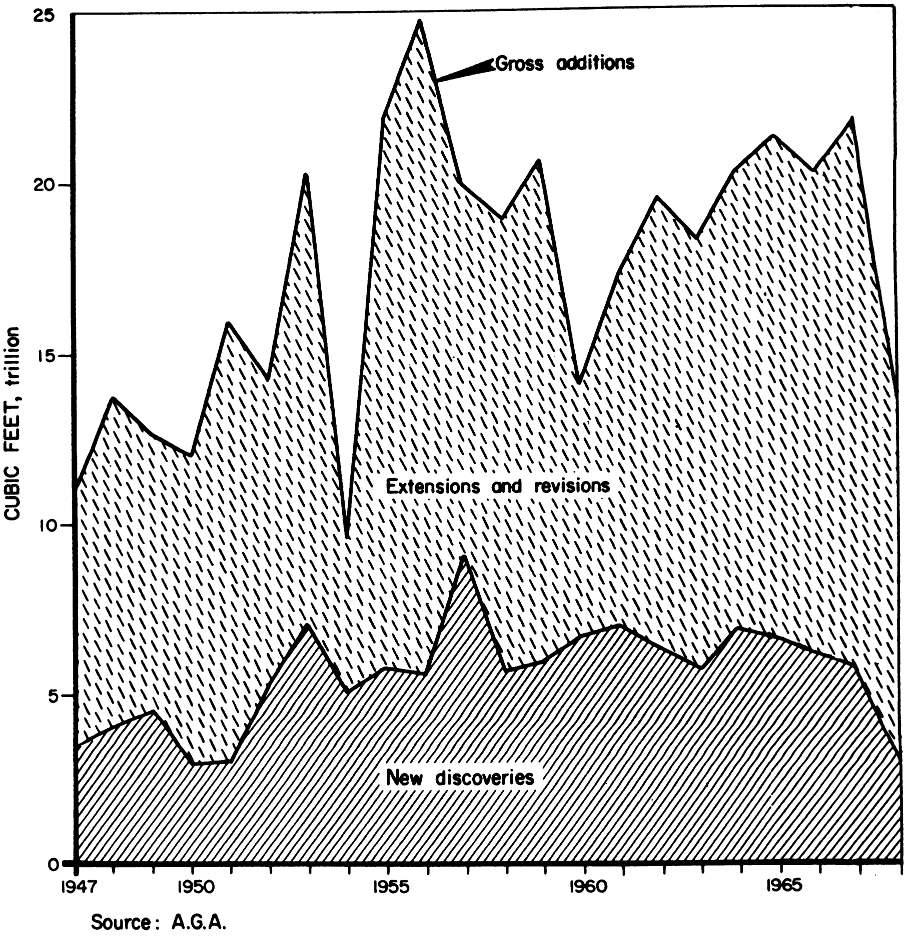

Figure 3.—Trends in annual gross additions to natural gas reserves.

approximately one-third of the nation's total undiscovered supply), and an assumption of greater drilling depths. Specifically, whereas the 1966 estimate assumed drilling depth limitations of 600 feet for offshore wells and 25,000 feet for onshore wells, the current report assumes drilling to depths of 1,500 feet offshore and 30,000 feet onshore.

Index of Selected Jurisdictional Companies.—As of December 31, 1967, there were 119 pipeline companies subject to the Federal Power Commission's jurisdiction, which were engaged in the sale or transportation of natural gas. Ninety five of these companies filed with the Federal Power Commission annual reports of gas supply (Form 15 and Form 15–A) for 1967, together with the total volumes of gas which they reported as purchased and produced, the percent of these volumes sold under firm and interruptible sales contracts, and jurisdictional sales for resale made during 1967. A complete list of these companies is available in the Federal Power Commission's publication, "The Gas Supplies of Interstate Natural Gas Pipeline Companies, 1967." Shown below is a list of 24 companies which have over 1 trillion cubic feet of domestic natural gas reserves.

Arkansas Louisiana Gas Co.
Cities Service Gas Co.
Colorado Interstate Gas Co.
Consolidated Gas Supply Corp.
El Paso Natural Gas Co.
Florida Gas Transmission Co.
Kansas-Nebraska Natural Gas Co., Inc.
Michigan Wisconsin Pipe Line Co.
Montana-Dakota Utilities Co.
Mountain Fuel Supply Co.
Natural Gas Pipeline Co. of America
Northern Natural Gas Co.
Panhandle Eastern Pipe Line Co.
South Texas Nat. Gas Gathering Co.
Southern Natural Gas Co.
Tennessee Gas Pipeline Co. (Tenneco, Inc.)
Texas Eastern Transmission Corp.
Texas Gas Transmission Corp.
Transco. Gas Pipe Line Corp.
Transwestern Pipeline Co.
Trunkline Gas Co.
United Fuel Gas Co.
United Gas Pipe Line Co.
West Texas Gathering Co.

PRODUCTIVE CAPACITY

The Committee on Natural Gas Reserves of the AGA has prepared estimates of the productive capacity of the natural gas industry as of December 31, 1968. The capacity for nonassociated reservoirs is estimated at 83,145 million cubic feet per day, and from associated-dissolved, 22,740 million cubic feet per day, as shown in table 9. The productive capacity of natural gas from nonassociated reservoirs is defined as the maximum daily rate at which such gas can be produced from natural reservoirs under specified conditions on March 31 of any given year. The productive capacity of associated-dissolved gas is based on the productive capacity of crude oil and the estimated producing gas-oil ratios which would result from such capacity operation during the first 90 days of a given year.

The productive capacity of associated gas from gas wells is usually based on the volumetric withdrawal of crude oil from related oil wells at capacity rates during the first 90 days of a given year.

STORAGE

The development of underground gas storage facilities expanded at an accelerated rate in 1968 and reservoir capacity increased 263.6 billion cubic feet to nearly 4.8 trillion cubic feet by yearend as indicated in table 10.

The ability to store gas in these underground facilities close to major markets during off-season periods has been a dominant factor in the industry's growth. Although the industry in 1968 added 100 billion cubic feet of natural gas to underground storage, withdrawals of more than 1.3 trillion cubic feet reduced stocks at the end of 1968 to 95,539 million cubic feet as shown in table 12.

In addition to underground storage, there is the growth in aboveground storage for liquefied natural gas (LNG). At present most of this type of storage is associated with peak shaving facilities of gas distributing utilities. The continued growth and expansion of the natural gas industry has created a need for large volume storage near metropolitan areas to meet the winter peak loads. Requirements for natural gas on a peak winter day is currently about 7 times that required on a summer day because of the growth in use of natural gas for home heating. This places a heavy burden on a local gas utility to supply the gas when needed, particularly if there is a prolonged cold spell; hence, the growth in LNG facilities.

In the United States there are 13 LNG plants either under construction or in operation and all of them are peak shaving operations. Relatively small amounts of gas are liquefied over a long period—from 200 to 300 days per year—and stored for use during peak winter loads. The primary purpose of liquefaction is storage. By lowering the temperature at atmospheric pressure to approximately minus 260° F its volume contracts by a factor of 600 during liquefaction.

During 1968, the Boston Gas Company, faced with a peak load supply problem, contracted to purchase LNG from Algeria to provide the extra gas for the coldest days. Two shiploads of liquid gas were provided from the Algerian plant at Camel to the Boston Gas Company's above ground LNG storage facility. This was an emergency step as the completion of a section of a natural gas pipeline had been blocked by suburban property owners. This problem, however, has been resolved and the line is connected with the company's liquefaction plant to liquefy natural gas and store it for peak winter needs.

In addition to peak shaving, the Philadelphia Gas Works plans to use liquid natural gas as motor fuel for part of its motor vehicle fleet. As to sources of supply, the company has been studying the possibilities of obtaining natural gas from sources such as Venezuela, Libya, Algeria, Nigeria, and Trinidad.

VALUE AND PRICE

The average value of natural gas at the wellhead increased 0.4 cent to 16.4 cents per thousand cubic feet (Mcf). Prices at the wellhead, however, range widely with the highest price in States near large consumer markets. In New York, for example, the wellhead price of natural gas is 31.9 cents; in California, 30.9. Prices near the large eastern markets are 26.2 cents for West Virginia and 27.8 cents for Pennsylvania. Other prices are shown in table 2. The average cost of natural gas, of course, varies widely because of transportation costs. In Maine, New Hampshire, and Vermont, for example, the price to residential consumers was $2.05 per Mcf in 1968 as compared with 87 cents in Texas based on quantities and values shown in table 5. In West Virginia, which is a producer of natural gas and which has an average wellhead price of 26.2 cents per Mcf, the price of gas to residential consumers is 87 cents a Mcf or nearly the same paid by a residential user in Texas.

Costs to commercial consumers follow the same pattern as indicated with residential uses—that is, the highest prices are in New England; the lowest in the West South Central States of Arkansas, Louisiana, Oklahoma, and Texas. The average price of natural gas to commercial users in the latter region was 52.4 cents a Mcf in 1968. In New England, a commercial user paid 148.8 cents per Mcf. Industrial accounts, excluding the electric utilities, averaged 34 cents. In the West South Central Region the average was about 21 cents; New England, 63 cents. In the East North Central Region, with consumption second only to that in the Southwest, the average price for an industrial customer was about 48.8 cents per Mcf.

The total of marketed production of natural gas was $3,168.7 million in 1968 or 9 percent higher than the $2,898.7 million of 1967 as shown in table 2. The total value of all the natural gas used in 1968 aggregated $9.8 billion, which was $357.5 million, or 3.8 percent above the values estimated for 1967.

FOREIGN TRADE

Foreign trade in natural gas is increasing steadily in magnitude, particularly imports. During 1968, imports rose to 651.9 billion cubic feet which was 87.7 billion, or 15.5 percent, higher than in 1967. Most of United States imports are from Canada and enter at Noyes, Minn.; Eastport, Idaho, and Sumas, Wash. Imports in these regions in 1968 accounted for 561.5 billion cubic feet or 86 percent of total imports. Another 43 billion cubic feet, imported from Canada, entered the United States to supply gas utility systems in Montana, upper New York State, and Vermont. Conversely, imports from Mexico dropped in 1968 to 47.4 billion cubic feet or 7 percent.

Exports of natural gas, similar to the pattern for imports, involved both Canada and Mexico. Exports to Canada in 1968 rose to 81.6 billion cubic feet or 15.9 percent above those in 1967. One point of exit into Canada is near St. Clair and Sault Ste. Marie, Mich., and exports from the United States in that area were nearly 48 billion cubic feet, almost a fourfold increase. However, the opposite occurred with exports from the Detroit, Mich., and the Niagara Falls, N.Y., areas, which were down to 33.6 billion cubic feet, or 41.5 percent below 1967 figures.

Exports to Mexico which exit the United States from Arizona and Texas were 12 billion cubic feet, or 8.6 percent, higher than in 1967.

The first large-scale commercial export of liquefied natural gas (LNG) from the United States is a joint venture of the Phillips Petroleum Company and the Marathon Oil Company to market Alaskan gas reserves. A sale has been negotiated in Japan for about 139 million cubic feet per day (MMcfd) of liquefied natural gas (LNG) to the Tokyo Electric Power Company, Inc., and the Tokyo Gas Company for an initial 15-year term. The American companies have constructed facilities to liquefy the natural gas for transport to Japan. Also involved is construction of two LNG tankers to deliver the cargoes. First deliveries are scheduled for the fourth quarter of 1969.

WORLD REVIEW

The United States, the Soviet Union, Canada, and Rumania lead the World in production of natural gas, and in 1968 the Netherlands forged ahead of Italy to become the world's fifth largest gas producing country. Since 1964, the Netherlands has more than doubled production each year and 1968 was no exception, as shown in table 14. The Netherlands has become the focal point in gas as it has the world's largest gas reserve at Groningen. Some of the gas produced in the Netherlands is moving into markets in West Germany, Belgium, and France. Marketed production in the United Kingdom increased more than fourfold—from 16,664 million cubic feet in 1967 to 71,335 million in 1968—as a result of development of gasfields in the North Sea. Production in the United Kingdom will move upward even faster in the future as the Hewitt Field, located some 20 miles off the eastern coast of Great Britain, started delivery of gas to the British Gas Council's distribution system soon after mid-1969. The United Kingdom's needs are being supplied in part by LNG shipped from Arzew, Algeria, to Canvey Island in the Thames Estuary. Gas from other North Sea gasfields is also entering the British market.

Natural gas use is rapidly becoming an important factor in the energy patterns of many other nations as large gasfields have been found in the Soviet Union, Algeria, United Arab Republic, Austria, Iran, Bolivia, Afghanistan, Pakistan, Canada, and France.

Next to Western Europe, gas usage in the Soviet Union is growing faster than any other part of the world. In 1968, as shown in table 14, the Soviet Union produced 6.0 trillion cubic feet of natural gas which is 10 times the 1958 production. Soviet gas now flows into eastern Europe and Austria began to import Soviet gas in September.

In Asia, a pipeline system is being built to transport gas from Iran's southern oilfields to the U.S.S.R. border of southern Azerbaijan. About 1.6 billion cubic feet daily will flow into that Soviet Socialist Republic.

As to Africa, movement of LNG from Algeria to Great Britain, France, and Spain has already been mentioned. The other important development, however, will be the movement of LNG from Libya to Italy and to Spain. The Esso Libya project involves the sale of 245 million standard cubic feet per day (scfd) of 1,350-Btu gas (equivalent to 465 scfd of 1,000-Btu gas) to Italy and to Spain. Technical difficulties developed in equipment before the gas was received at the liquefaction unit so that the startup has been delayed until the fall of 1969. Most of the gas to be liquefied is produced in association with oil. The gas will be liquefied at Marsa el Brega, Libya, and then transported in four LNG tankers to La Spezia, Italy, and Barcelona, Spain. Nearly all of the gas to be liquefied is associated gas from the Zelton field and the Reguba field in the Libyan Desert.

The Algerian State Company has signed an agreement with France, similar to its agreement with the United Kingdom. Spain has contracted for Algerian natural gas (LNG) over a 15-year period beginning in 1970.

Table 2.—Quantity and value of marketed production[1] of natural gas in the United States

State	1967			1968		
	Quantity (million cubic feet)	Value (thousands)	Average wellhead value, cents per Mcf	Quantity (million cubic feet)	Value (thousands)	Average wellhead value, cents per Mcf
Alabama	248	$31	12.7	230	$30	13.1
Alaska	14,438	3,610	25.0	17,343	4,388	25.1
Arizona	1,255	193	15.4	881	142	16.1
Arkansas	116,522	17,828	15.3	156,627	24,456	15.6
California	681,080	202,290	29.7	714,893	221,077	30.9
Colorado	116,857	15,542	13.3	121,424	16,392	13.5
Florida	123	18	14.8	108	16	14.8
Illinois	5,144	602	11.7	4,380	552	12.6
Indiana	198	46	23.4	234	55	23.5
Kansas	871,971	116,844	13.4	835,555	115,307	13.8
Kentucky	89,168	21,400	24.0	89,024	22,256	25.0
Louisiana	5,716,857	1,057,619	18.5	6,416,015	1,212,627	18.9
Maryland	621	159	25.6	864	221	25.6
Michigan	33,589	8,296	24.7	40,480	10,160	25.1
Mississippi	139,497	24,133	17.3	135,051	22,601	16.7
Missouri	121	30	24.5	14	4	28.6
Montana	25,866	2,173	8.4	19,313	1,757	9.1
Nebraska	8,453	1,454	17.2	8,129	1,428	17.5
New Mexico	1,067,510	138,776	13.0	1,164,182	156,000	13.4
New York	3,837	1,201	31.3	4,632	1,390	30.0
North Dakota	40,462	6,636	16.4	41,023	6,769	16.5
Ohio	41,315	9,957	24.1	42,673	10,540	24.7
Oklahoma	1,412,952	202,052	14.3	1,390,884	197,506	14.2
Pennsylvania	89,966	25,280	28.1	87,987	24,460	27.8
Tennessee	58	11	19.0	48	9	18.8
Texas	7,188,900	948,935	13.2	7,495,414	1,011,881	13.5
Utah	48,965	6,463	13.2	46,151	7,292	15.8
Virginia	3,818	1,149	30.1	3,389	1,013	29.9
West Virginia	211,460	50,962	24.1	236,971	62,086	26.2
Wyoming	240,074	35,051	14.6	248,481	36,278	14.6
Total	18,171,325	2,898,741	16.0	19,322,400	3,168,688	16.4

---

[1] Comprises gas either sold or consumed by producers, including gas loss due to natural gas liquids recovery, losses in transmission, quantities added to storage, and increases of gas in pipelines.

Table 3.—Marketed production, interstate shipments, and total consumption of natural gas in the United States in 1968

(Million cubic feet)

State by region	Marketed production	Interstate movements			Change in underground storage	Transmission loss and unaccounted for	Consumption
		Receipts	Deliveries	Net receipts or deliveries (−)			
New England:							
Connecticut	----------	142,353	87,094	55,259	----------	2,057	53,202
Maine, New Hampshire, and Vermont	----------	8,543	1,403	7,140	----------	510	6,630
Massachusetts	----------	150,594	13,703	136,891	102	4,464	132,325
Rhode Island	----------	92,031	70,649	21,382	----------	678	20,704
Total	----------	393,521	172,849	220,672	102	7,709	212,861
Middle Atlantic:							
New Jersey	----------	741,435	460,243	281,192	7	12,690	268,495
New York	4,632	890,259	242,064	648,195	−504	13,486	639,845
Pennsylvania	87,987	1,891,020	1,222,364	668,656	−155	38,773	718,025
Total	92,619	3,522,714	1,924,671	1,598,043	−652	64,949	1,626,365
East North Central:							
Illinois	4,380	2,144,948	1,066,373	1,078,575	46,034	28,860	1,008,061
Indiana	234	1,754,225	1,288,462	465,763	1,773	10,211	454,013
Michigan	40,480	742,934	68,045	674,889	4,491	7,096	703,782
Ohio	42,673	2,672,596	1,712,919	959,677	11,041	3,468	987,841
Wisconsin	----------	292,179	15,733	276,446	----------	4,681	271,765
Total	87,767	7,606,882	4,151,532	3,455,350	63,339	54,316	3,425,462
West North Central:							
Iowa	----------	1,240,460	935,395	305,065	2,508	5,059	297,498
Kansas	835,555	1,841,240	2,129,987	−288,747	3,334	17,882	525,592
Minnesota	----------	453,846	142,839	311,007	----------	−891	311,898
Missouri	14	1,611,649	1,246,146	365,503	−1,248	1,219	365,546
Nebraska	8,129	1,229,265	1,031,229	198,036	−805	2,831	204,139
North Dakota	41,023	7,191	9,350	−2,159	----------	383	38,481
South Dakota	----------	30,409	1,149	29,260	----------	445	28,815
Total	884,721	6,414,060	5,496,095	917,965	3,789	26,928	1,771,969
South Atlantic:							
Delaware	----------	26,095	1,750	24,345	245	41	24,059
Florida	108	277,626	----------	277,626	----------	2,200	275,534
Georgia	----------	1,208,829	917,165	291,664	----------	8,549	283,115
Maryland and District of Columbia	864	766,725	610,974	155,751	4,285	3,205	149,125
North Carolina	----------	763,794	648,101	115,693	----------	884	114,809
South Carolina	----------	895,084	763,794	131,290	----------	3,776	127,514
Virginia	3,389	868,322	745,344	122,978	168	4,271	121,928

Table 3.—Marketed production, interstate shipments, and total consumption of natural gas in the United States in 1968—Continued

(Million cubic feet)

State by region	Marketed production	Interstate movements: Receipts	Interstate movements: Deliveries	Interstate movements: Net receipts or deliveries (−)	Change in underground storage	Transmission loss and unaccounted for	Consumption
West Virginia	236,971	1,299,699	1,345,085	−45,386	−1,644	4,202	189,027
Total	241,332	6,106,174	5,032,213	1,073,961	3,054	27,128	1,285,111
East South Central:							
Alabama	230	2,929,775	2,641,104	288,671	27	1,662	287,212
Kentucky	89,024	3,340,555	3,215,291	125,264	944	7,964	205,380
Mississippi	135,051	5,515,327	5,338,335	176,992	194	−1,013	312,862
Tennessee	48	3,574,364	3,332,244	242,120	234	7,646	234,288
Total	224,353	15,360,021	14,526,974	833,047	1,399	16,259	1,039,742
West South Central:							
Arkansas	156,627	2,505,614	2,329,995	175,619	356	6,654	325,236
Louisiana	6,416,015	1,219,066	5,941,616	−4,722,550	10,238	21,445	1,661,782
Oklahoma	1,390,884	1,293,066	2,119,168	−826,102	10,407	2,186	552,189
Texas	7,495,414	435,771	3,759,024	−3,323,253	−2,645	21,293	4,153,513
Total	15,458,940	5,453,517	14,149,803	−8,696,286	18,356	51,578	6,692,720
Mountain:							
Arizona	881	1,377,431	1,200,981	176,450	----------	784	176,547
Colorado	121,424	250,125	105,486	144,639	−1	4,698	261,366
Idaho	----------	377,680	337,505	40,175	----------	696	39,479
Montana	19,313	66,759	12,385	54,374	9,389	656	63,642
Nevada	----------	37,376	----------	37,376	----------	347	37,029
New Mexico	1,164,182	689,089	1,537,473	−848,384	14	6,375	309,409
Utah	46,151	229,148	161,188	67,960	29	950	113,132
Wyoming	248,481	93,424	247,815	−154,391	1,267	2,632	90,191
Total	1,600,432	3,121,032	3,602,833	−481,801	10,698	17,138	1,090,795
Pacific:							
Alaska	17,343	----------	----------	----------	----------	−205	17,548
California	714,893	1,416,580	----------	1,416,580	−4,546	57,300	2,078,719
Oregon	----------	320,466	240,631	79,835	----------	609	79,226
Washington	----------	439,285	298,511	140,774	----------	1,353	139,421
Total	732,236	2,176,331	539,142	1,637,189	−4,546	59,057	2,314,914
Total United States	19,322,400	[1] 50,154,252	[2] 49,596,112	558,140	95,539	325,062	19,459,939

[1] Includes receipts from Canada of 291,801 MMcf into Idaho; 148,848 MMcf into Washington; 120,862 MMcf into Minnesota; 36,635 MMcf into Montana; 4,869 MMcf into New York; 1,452 MMcf into Vermont and from Mexico 47,423 MMcf into Texas.

[2] Includes deliveries into Canada of 68,044 MMcf from Michigan; 13,499 MMcf from New York; 104 MMcf from Montana and into Mexico 8,206 MMcf from Texas and 3,891 MMcf from Arizona.

Table 4.—Net interstate pipeline movements of natural gas in the United States, 1968

(Billion cubic feet at 14.73 psia)

Region and State and State Abbreviation	Net receipt or delivery (−)	Moved from—						Moved to—					
		State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity
New England:													
Connecticut (CT)	55.3	NY	139.3	MA	3.1	----	-------	RI	87.1	----	-------	----	--------
Maine (ME), New Hampshire (NH), Vermont (VT)	7.2	MA	5.7	CN	1.5	----	-------	----	-------	----	-------	----	--------
Massachusetts (MA)	136.8	NY	79.9	RI	70.6	----	-------	NH	5.7	RI	4.9	CT	3.1
Rhode Island (RI)	21.4	CT	87.1	MA	4.9	----	-------	MA	70.6	----	-------	----	--------
Total	220.7	NY	219.2	CN	1.5	----	-------	----	-------	----	-------	----	--------
Middle Atlantic:													
New Jersey (NJ)	281.3	PA	741.0	NY	.5	----	-------	NY	460.2	----	-------	----	--------
New York (NY)	648.1	NJ	460.2	PA	425.1	CN	4.9	CT	139.3	MA	79.9	CN	13.5
	---------	----	-------	----	-------	----	-------	PA	8.9	NJ	.5	----	--------
Pennsylvania (PA)	668.8	WV	777.7	MD	599.7	OH	504.8	NJ	741.0	NY	425.1	DE	26.1
	---------	NY	8.9	----	-------	----	-------	OH	17.0	MD	8.2	WV	4.9
Total	1,598.2	WV	772.8	MD	591.5	OH	487.8	CT	139.3	MA	79.9	DE	26.1
	---------	CN	4.9	----	-------	----	-------	CN	13.5	----	-------	----	--------
East North Central:													
Illinois (IL)	1,078.5	MO	1,023.0	IA	591.5	KY	427.3	IN	912.7	WI	153.7	----	--------
	---------	IN	103.1	----	-------	----	-------	----	-------	----	-------	----	--------
Indiana (IN)	465.8	IL	912.7	KY	841.5	----	-------	OH	999.8	IL	103.1	MI	185.5
Michigan (MI)	674.9	OH	541.7	IN	185.5	WI	15.7	CN	68.0	----	-------	----	--------
Ohio (OH)	959.7	KY	1,322.3	IN	999.8	WV	333.5	WV	666.4	MI	541.7	PA	504.8
	---------	PA	17.0	----	-------	----	-------	----	-------	----	-------	----	--------
Wisconsin (WI)	276.5	IL	153.7	MN	138.5	----	-------	MI	15.7	----	-------	----	--------
Total	3,455.4	KY	2,591.1	MO	1,023.0	IA	591.5	PA	487.8	WV	332.9	CN	68.0
	---------	MN	138.5	----	-------	----	-------	----	-------	----	-------	----	--------
West North Central:													
Iowa (IA)	305.2	NB	1,020.5	MO	219.6	SD	.4	IL	591.5	MN	332.6	SD	11.2
Kansas (KA)	−288.9	OK	1,838.2	MO	3.0	----	-------	NB	1,206.9	MO	838.7	CO	55.9
	---------	----	-------	----	-------	----	-------	OK	28.6	----	-------	----	--------
Minnesota (MN)	311.0	IA	332.6	CN	120.9	SD	.3	WI	138.5	ND	4.3	----	--------
Missouri (MO)	365.4	KA	838.7	AR	768.3	OK	4.6	IL	1,023.0	IA	219.6	KS	3.0
	---------	----	-------	----	-------	----	-------	AR	.6	----	-------	----	--------
Nebraska (NB)	198.1	----	1,206.9	WY	18.2	CO	4.2	IA	1,020.5	SD	9.7	CO	1.0
North Dakota (ND)	−2.2	MN	4.3	MT	2.9	----	-------	MT	9.4	----	-------	----	--------
South Dakota (SD)	29.2	IA	11.2	NB	9.7	MT	9.4	WY	.4	IA	.4	MN	.3
Total	917.8	OK	1,814.2	CN	120.9	AR	767.7	IL	1,614.5	WI	138.5	CO	52.7
	---------	WY	17.8	MT	2.9	----	-------	----	-------	----	-------	----	--------

Table 4.—Net interstate pipeline movements of natural gas in the United States, 1968—Continued

(Billion cubic feet at 14.73 psia)

Region and State and State Abbreviation	Net receipt or delivery (−)	Moved from—						Moved to—					
		State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity	State	Quantity
South Atlantic:													
Delaware (DE)	24.3	PA	26.1	----	-------	----	-------	MD	1.8	----	-------	----	--------
Florida (FL)	267.7	AL	267.7	----	-------	----	-------	----	--------	----	-------	----	--------
Georgia (GA)	301.5	AL	1,207.7	TN	1.1	----	-------	SC	895.1	TN	12.2	----	--------
Maryland & D.C. (MD)	155.7	VA	740.6	PA	8.2	WY	4.8	PA	599.7	----	-------	----	--------
	---------	DE	1.8	----	-------	----	-------	----	--------	----	-------	----	--------
North Carolina (NC)	115.7	SC	763.8	----	-------	----	-------	VA	648.1	----	-------	----	--------
South Carolina (SC)	131.3	GA	895.1	----	-------	----	-------	NC	768.8	----	-------	----	--------
Virginia (VA)	123.0	NC	648.1	WY	216.6	TN	3.6	MD	740.6	WV	4.2	KY	.5
West Virginia (WV)	−45.5	OH	666.4	KY	624.1	PA	4.9	PA	777.7	OH	333.5	VA	216.6
	---------	VA	4.2	----	-------	----	-------	KY	12.5	MD	4.8	----	--------
Total	1,073.7	AL	1,475.4	KY	611.1	OH	332.9	PA	1,338.2	TN	7.5	----	--------
East South Central:													
Alabama (AL)	288.7	MS	2,929.8	----	-------	----	-------	GA	1,207.7	TN	1,162.7	FL	267.7
	---------	----	-------	----	-------	----	-------	MS	3.0	----	-------	----	--------
Kentucky (KY)	125.4	TN	3,327.6	WV	12.5	VA	.5	OH	1,322.3	IN	841.5	WV	624.1
	---------	----	-------	----	-------	----	-------	IL	427.3	----	-------	----	--------
Mississippi (MS)	176.9	LA	3,958.1	AR	1,554.1	AL	3.0	AL	2,929.8	TN	2,399.5	LA	9.0
Tennessee (TN)	242.1	MS	2,399.5	AL	1,162.7	GA	12.2	KY	3,327.6	VA	3.6	GA	1.1
Total	833.1	LA	3,949.1	AR	1.554.1	----	-------	OH	1,322.3	GA	1,196.6	IN	841.5
	---------	----	-------	----	-------	----	-------	WV	611.6	IL	427.3	FL	267.7
	---------	----	-------	----	-------	----	-------	VA	3.1	----	-------	----	--------
West South Central:													
Arkansas (AR)	175.6	LA	1,826.3	TX	588.5	OK	90.1	LA	.4	MS	1,554.1	MO	768.3
	---------	MO	.6	----	-------	----	-------	TX	7.1	----	-------	----	--------
Louisiana (LA)	−4,722.4	TX	1,209.7	MS	9.0	AR	.4	AR	1,826.3	MS	3,958.1	TX	157.1
Oklahoma (OK)	−825.9	TX	1,264.5	KS	28.6	----	-------	KS	1,838.2	TX	101.3	AR	90.1
	---------	----	-------	----	-------	----	-------	CO	84.8	MO	4.6	----	--------
Texas (TX)	−3,323.3	LA	157.1	NM	122.8	OK	101.3	AR	588.5	LA	1,209.7	NM	688.1
	---------	MX	47.4	AR	7.1	----	-------	OK	1,264.5	MX	8.2	----	--------
Total	−8,696.0	MX	47.4	----	-------	----	-------	MS	5,503.2	KS	1,809.6	MO	772.3
	---------	----	-------	----	-------	----	-------	NM	565.3	CO	84.8	MX	8.2
Mountain:													
Arizona (AZ)	176.5	NM	1,376.5	UT	1.0	----	-------	CA	1,177.2	NV	18.9	MX	3.9
	---------	----	-------	----	-------	----	-------	NM	1.0	----	-------	----	--------
Colorado (CO)	144.7	OK	84.8	WY	70.3	KS	55.9	UT	90.6	WY	10.7	NB	4.2
	---------	NM	38.2	NB	1.0	----	-------	----	--------	----	-------	----	--------
Idaho (ID)	40.2	CN	291.8	UT	78.0	WA	7.9	WA	289.2	OR	29.9	NV	18.4
Montana (MT)	54.4	CN	86.3	WY	20.8	ND	9.4	SD	9.4	ND	2.9	CN	.1

Nevada (NV)	37.3	AZ	18.9	ID	18.4	----	-------	----	-------	----	-------	----	--------
New Mexico (NM)	−848.4	TX	688.1	AZ	1.0	----	-------	AZ	1,376.5	TX	122.8	CO	38.2
Utah (UT)	67.9	WY	138.6	CO	90.6	----	-------	WY	82.3	ID	78.0	AZ	1.0
Wyoming (WY)	−154.5	UT	82.8	CO	10.7	SD	.4	UT	138.6	CO	70.3	MT	20.8
	---------	----	-------	----	-------	----	-------	NB	18.2	----	-------	----	--------
Total	−481.9	TX	565.3	CN	328.4	OK	84.8	CA	1,177.2	WA	281.3	NB	21.4
	---------	KS	55.9	ND	6.5	----	-------	SD	9.0	OR	29.9	MX	3.9
	---------	----	-------	----	-------	----	-------	CN	.1	----	-------	----	--------
Pacific:													
Alaska (AK)	---------	----	-------	----	-------	----	-------	----	-------	----	-------	----	--------
California (CA)	1,416.6	AZ	1,177.2	OR	239.4	----	-------	----	-------	----	-------	----	--------
Oregon (OR)	79.9	WA	290.6	ID	29.9	----	-------	CA	239.4	WA	1.2	----	--------
Washington (WA)	140.7	ID	289.2	CN	148.8	OR	1.2	OR	290.6	ID	7.9	----	--------
Total	1,637.2	AZ	1,177.2	ID	311.2	CN	148.8	----	-------	----	-------	----	--------
United States, total	558.2	----	-------	----	-------	----	-------	----	-------	----	-------	----	--------
Foreign:													
Canada (CN)	---------	----	604.5	----	-------	----	-------	----	81.6	----	-------	----	--------
Mexico (MX)	---------	----	47.4	----	-------	----	-------	----	12.1	----	-------	----	--------

Note: Detail figures may not add to totals shown because of independent rounding.

Table 5.—Quantity and value of natural gas delivered

Region and State	Residential			Commercial		
	Number of consumers (thousands)	Quantity (MMcf)[1]	Value (thousands)	Number of consumers (thousands)	Quantity (MMcf)[1]	Value (thousands)
New England:						
Connecticut	357	26,437	$47,921	25	8,379	$12,767
Maine, New Hampshire, Vermont	60	3,571	7,324	4	1,288	2,105
Massachusetts	969	74,919	139,072	61	22,835	33,550
Rhode Island	149	10,605	18,846	8	3,168	4,642
Total	1,535	115,532	213,163	98	35,670	53,064
Middle Atlantic:						
New Jersey	1,554	137,116	262,372	165	29,011	42,961
New York	3,842	319,282	441,886	269	106,394	131,716
Pennsylvania	2,207	285,978	328,016	138	81,242	73,516
Total	7,603	742,376	1,032,274	572	216,647	248,193
East North Central:						
Illinois	2,679	392,325	401,626	190	170,733	126,684
Indiana	962	145,955	136,468	95	58,764	47,423
Michigan	1,812	315,694	308,391	152	115,075	93,528
Ohio	2,391	444,964	380,444	183	147,513	108,885
Wisconsin	717	93,425	102,487	55	33,415	29,673
Total	8,561	1,392,363	1,329,416	675	525,500	406,193
West North Central:						
Iowa	545	84,936	79,383	64	47,792	31,634
Kansas	565	89,372	55,988	57	40,162	18,146
Minnesota	564	90,410	93,193	49	41,685	30,629
Missouri	936	138,764	119,476	91	66,736	44,780
Nebraska	307	53,376	42,434	46	30,937	17,278
North Dakota	46	7,169	6,703	6	6,561	4,159
South Dakota	71	10,302	10,200	10	8,574	5,381
Total	3,034	474,329	407,377	323	242,447	152,007
South Atlantic:						
Delaware	75	7,068	11,270	5	2,084	2,638
Florida	345	11,318	29,359	26	18,720	20,542
Georgia	705	84,072	85,669	53	34,183	23,826
Maryland and District of Columbia	791	79,015	112,107	62	27,807	31,862
North Carolina	268	24,646	31,898	35	13,531	14,963
South Carolina	199	16,756	22,167	23	10,112	9,839
Virginia	448	43,582	62,709	47	20,979	21,934
West Virginia	343	54,665	47,505	30	17,355	12,249
Total	3,174	321,122	402,684	281	144,771	137,853
East South Central:						
Alabama	525	51,708	56,624	38	33,485	18,898
Kentucky	495	75,824	60,214	47	28,667	18,967
Mississippi	297	29,526	28,729	35	14,980	8,525
Tennessee	378	43,784	38,728	49	35,128	24,968
Total	1,695	200,842	184,295	169	112,260	71,358
West South Central:						
Arkansas	357	56,346	39,499	47	35,785	17,928
Louisiana	804	77,762	57,933	72	31,633	14,962
Oklahoma	612	74,782	57,842	64	32,478	16,930
Texas	2,393	211,763	184,234	240	91,010	50,239
Total	4,166	420,653	339,508	423	190,906	100,059
Mountain:						
Arizona	380	26,681	25,801	36	15,732	8,464
Colorado	484	78,371	53,136	63	46,153	25,476

See footnotes at end of table.

to consumers by type of consumer and by States, 1968

Industrial [3]		Electric utilities		Other consumers [5]		Total	
Quantity [3] (MMcf)[1]	Value (thousands)	Quantity [4] (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)
15,045	$1,508	439	$136	2,845	$3,442	53,145	$65,774
1,387	1,243	----------	----------	384	328	6,630	11,000
22,379	20,723	7,982	2,546	2,561	2,291	130,676	198,182
5,188	4,299	1,492	522	248	321	20,701	28,630
43,999	27,773	9,913	3,204	6,038	6,382	211,152	303,586
70,850	40,314	27,523	8,339	3,535	1,579	268,035	355,565
91,679	58,308	102,137	38,404	16,491	14,341	635,983	684,655
314,913	168,478	4,355	1,446	6,378	5,282	692,866	576,738
477,442	267,100	134,015	48,189	26,404	21,202	1,596,884	1,616,958
336,393	154,741	73,122	20,328	3,832	1,391	976,405	704,770
231,137	97,540	6,508	1,829	1,897	1,312	444,261	284,572
250,906	130,471	6,582	2,159	2,049	1,310	690,306	525,859
350,281	182,847	11,060	3,948	17,901	12,546	971,719	688,670
117,315	61,708	22,275	7,484	2,652	888	269,082	202,240
1,286,032	627,307	119,547	35,748	28,331	17,447	3,351,773	2,416,111
82,646	30,579	69,273	18,773	242	56	284,889	160,425
147,183	35,324	138,730	38,151	6,070	1,734	421,517	149,343
88,518	33,089	64,675	16,039	23,851	10,436	309,139	183,386
94,287	33,731	43,319	10,310	13,085	3,997	356,191	212,294
48,166	14,695	48,103	12,555	10,828	3,030	191,410	89,992
2,612	927	31	11	511	344	16,884	12,144
4,101	1,271	3,666	979	2,149	889	28,792	18,720
467,513	149,616	367,797	96,818	56,736	20,486	1,608,822	826,304
11,377	7,782	3,530	1,147	----------	----------	24,059	22,837
88,299	33,164	147,566	47,959	3,170	834	269,073	131,858
140,115	51,843	16,417	4,383	1,851	1,387	276,638	167,108
37,514	24,834	436	121	2,612	2,612	147,384	171,536
60,538	30,027	4,172	1,310	7,093	3,497	109,980	81,695
68,641	28,486	28,935	8,767	432	213	124,876	69,472
42,493	20,949	3,471	989	3,615	2,340	114,140	108,921
88,069	39,575	791	226	3,047	2,124	163,927	101,679
537,046	236,660	205,318	64,902	21,820	13,007	1,230,077	855,106
171,755	55,105	11,465	2,648	1,264	600	269,677	133,875
51,969	22,866	349	95	7,422	4,216	164,231	106,358
119,590	33,215	83,544	21,889	3,317	812	250,957	93,170
107,476	39,766	21,542	4,524	3,197	1,500	211,127	109,486
450,790	150,952	116,900	29,156	15,200	7,128	895,992	442,889
138,997	39,352	72,045	18,275	2,101	634	305,274	115,688
864,848	192,861	252,831	53,601	25,304	6,205	1,252,378	325,562
118,948	28,666	161,852	30,104	10,273	3,329	398,333	136,871
1,696,231	330,765	852,173	21,475	48,432	11,612	2,899,609	598,325
2,819,024	591,644	1,338,901	123,455	86,110	21,780	4,855,594	1,176,446
54,613	19,879	45,943	14,105	7,657	3,017	150,626	71,266
83,683	22,343	43,431	9,511	1,134	396	252,772	110,862

Table 5.—Quantity and value of natural gas delivered

Region and State	Residential			Commercial		
	Number of consumers (thousands)	Quantity (MMcf)[1]	Value (thousands)	Number of consumers (thousands)	Quantity (MMcf)[1]	Value (thousands)
Mountain—Continued						
Idaho	62	6,545	8,885	10	5,828	5,460
Montana	131	19,711	16,202	17	11,529	6,929
Nevada	61	5,493	8,305	3	4,006	3,629
New Mexico	239	31,568	28,064	26	16,683	10,210
Utah	235	40,779	30,340	15	8,098	4,589
Wyoming	68	12,592	8,374	10	10,713	4,832
Total	1,660	221,740	179,107	180	118,742	69,589
Pacific:						
Alaska	11	2,293	3,478	2	3,057	2,992
California	5,418	517,636	482,699	344	186,888	128,524
Oregon	169	15,126	23,350	22	7,827	10,635
Washington	233	26,342	37,564	32	15,928	17,544
Total	5,831	561,397	547,091	400	213,700	159,695
Total United States	37,259	4,450,354	4,634,915	3,121	1,800,643	1,398,011

[1] Quantities in million cubic feet at 14.73 psia.
[2] Includes refinery fuel use.
[3] Includes 104,973 million cubic feet used for carbon black production.
[4] Source: Federal Power Commission.
[5] Includes deliveries to municipalities and public authorities for institutional heating, street lighting, etc.

to consumers by type of consumer and by States, 1968—Continued

Industrial[2]		Electric utilities		Other consumers[5]		Total	
Quantity[3] (MMcf)[1]	Value (thousands)	Quantity[4] (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)
24,637	10,643	----------	----------	546	260	37,556	25,248
23,155	7,570	631	150	2,122	834	57,148	31,685
8,693	3,974	15,846	6,053	2,991	1,854	37,029	23,815
76,864	19,293	49,236	13,589	14,030	4,311	188,381	75,467
53,639	15,652	5,587	1,564	16	11	108,119	52,156
34,794	8,262	316	65	924	182	59,339	21,715
360,078	107,616	160,990	45,037	29,420	10,865	890,970	412,214
2,677	1,205	5,625	2,019	1,656	579	15,308	10,273
544,292	204,110	684,315	236,089	3,015	1,869	1,936,146	1,053,291
51,755	21,737	537	199	47	24	75,292	55,945
93,370	36,414	----------	----------	316	158	135,956	91,680
692,094	263,466	690,477	238,307	5,034	2,630	2,162,702	1,211,189
7,134,018	2,422,134	3,143,858	684,816	275,093	120,927	16,803,966	9,260,803

Table 6.—Consumption of natural gas by use and by States, 1968

Region and State	Delivered to consumers		Extraction loss		Lease and plant fuel		Pipeline fuel		Total	
	Quantity (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)	Quantity (MMcf)[1]	Value (thousands)
New England:										
Connecticut	53,145	65,774	---------	---------	---------	---------	57	$39	53,202	$65,818
Maine, New Hampshire, Vermont	6,630	11,000	---------	---------	---------	---------	---------	---------	6,630	11,000
Massachusetts	130,676	198,182	---------	---------	---------	---------	1,649	434	132,325	198,616
Rhode Island	20,701	28,630	---------	---------	---------	---------	3	1	20,704	28,631
Total	211,152	303,586	---------	---------	---------	---------	1,709	474	212,861	304,060
Middle Atlantic:										
New Jersey	268,035	355,565	---------	---------	---------	---------	460	97	268,495	355,662
New York	635,983	684,655	---------	---------	538	$233	3,324	760	639,845	685,648
Pennsylvania	692,866	576,738	116	$35	1,530	603	23,513	5,693	718,025	583,069
Total	1,596,884	1,616,958	116	35	2,068	836	27,297	6,550	1,626,365	1,624,379
East North Central:										
Illinois	976,405	704,770	13,657	2,404	473	---------	17,526	3,454	1,008,061	710,628
Indiana	444,261	284,572	---------	---------	---------	---------	9,752	2,032	454,013	286,604
Michigan	690,306	535,859	3,244	801	2,012	239	8,220	2,182	703,782	539,081
Ohio	971,719	688,670	---------	---------	3,505	1,229	12,617	2,876	987,841	692,775
Wisconsin	269,082	202,240	---------	---------	---------	---------	2,683	609	271,765	202,849
Total	3,351,773	2,416,111	16,901	3,205	5,990	1,468	50,798	11,153	3,425,462	2,431,937
West North Central:										
Iowa	284,889	160,425	---------	---------	---------	---------	12,609	2,028	297,498	162,453
Kansas	421,517	149,343	29,042	4,414	15,867	3,158	59,166	9,881	525,592	166,796
Minnesota	309,139	183,386	---------	---------	---------	---------	2,759	608	311,898	183,994
Missouri	356,191	212,294	---------	---------	---------	---------	9,355	1,871	365,546	214,165
Nebraska	191,410	89,992	794	132	1,945	356	9,990	1,453	204,139	91,933
North Dakota	16,884	12,144	5,428	858	16,163	2,590	6	1	38,481	15,593
South Dakota	28,792	18,720	---------	---------	---------	---------	23	5	28,815	18,725
Total	1,608,822	826,304	35,264	5,404	33,975	6,104	93,908	15,847	1,771,969	853,659
South Atlantic:										
Delaware	24,059	22,837	---------	---------	---------	---------	---------	---------	24,059	22,837
Florida	269,073	131,858	2,010	567	201	33	4,250	786	275,534	133,244
Georgia	276,638	167,108	---------	---------	---------	---------	6,477	1,231	283,115	168,339
Maryland and District of Columbia	147,384	171,536	---------	---------	310	143	1,431	265	149,125	171,944
North Carolina	109,980	81,695	---------	---------	---------	---------	4,829	897	114,809	82,592
South Carolina	124,876	69,472	---------	---------	---------	---------	2,638	516	127,514	69,988
Virginia	114,140	108,921	---------	---------	128	46	7,660	1,509	121,928	110,476
West Virginia	163,927	101,679	6,024	1,512	2,276	537	16,800	5,588	189,027	109,316
Total	1,230,077	855,106	8,034	2,079	2,915	759	44,085	10,792	1,285,111	868,736

East South Central:										
Alabama	269,677	133,875	---------	---------	152	58	17,383	3,390	287,212	137,323
Kentucky	164,231	106,358	8,573	1,612	1,992	364	30,584	8,380	205,380	116,714
Mississippi	250,957	93,170	971	191	9,158	1,537	51,776	10,159	312,862	105,057
Tennessee	211,127	109,486	---------	---------	753	170	22,408	4,405	234,288	114,061
Total	895,992	442,889	9,544	1,803	12,055	2,129	122,151	26,334	1,039,742	473,155
West South Central:										
Arkansas	305,274	115,688	3,667	870	4,027	757	12,268	2,214	325,236	119,529
Louisiana	1,252,378	325,562	140,290	39,421	212,134	---------	56,980	10,919	1,661,782	375,902
Oklahoma	398,333	136,871	55,724	9,807	84,259	11,963	13,873	2,137	552,189	160,778
Texas	2,899,609	598,325	457,117	148,106	711,720	133,312	85,067	14,263	4,153,513	894,006
Total	4,855,594	1,176,446	656,798	198,204	1,012,140	146,032	168,188	29,533	6,692,720	1,550,215
Mountain:										
Arizona	150,626	71,266	---------	---------	20	3	25,901	3,931	176,547	75,200
Colorado	252,772	110,862	4,546	686	2,361	303	1,687	290	261,366	112,141
Idaho	37,556	25,248	---------	---------	---------	---------	1,923	401	39,479	25,649
Montana	57,148	31,685	744	99	5,188	586	562	61	63,642	32,431
Nevada	37,029	23,815	---------	---------	---------	---------	---------	---------	37,029	23,815
New Mexico	188,381	75,467	48,635	5,982	46,331	5,399	26,062	3,986	309,409	90,834
Utah	108,119	52,156	3,266	558	1,503	231	244	51	113,132	52,996
Wyoming	59,339	21,715	11,390	1,583	17,271	2,278	2,191	361	90,191	25,937
Total	890,970	412,214	68,581	8,908	72,674	8,800	58,570	9,081	1,090,795	439,003
Pacific:										
Alaska	15,308	10,273	---------	---------	2,240	410	---------	---------	17,548	10,683
California	1,936,146	1,053,291	32,639	11,587	93,074	25,709	16,860	4,091	2,078,719	1,094,678
Oregon	75,292	55,945	---------	---------	---------	---------	3,934	808	79,226	56,753
Washington	135,956	91,680	---------	---------	---------	---------	3,465	722	139,421	92,402
Total	2,162,702	1,211,189	32,639	11,587	95,314	26,119	24,259	5,621	2,314,914	1,254,516
Total United States	16,803,966	9,260,803	827,877	231,225	1,237,131	192,247	590,965	115,385	19,459,939	9,799,660

---

[1] Quantities in million cubic feet at 14.73 psia.

Table 7.—Production of natural gas liquids at natural gas processing plants, and disposition of residue gas in the United States, by States

(Million cubic feet at 14.73 psia at 60° F unless otherwise stated)

State	Total natural gas liquids and ethane production (thousand barrels)[1]	Natural gas processed	Extraction loss (shrinkage)	Disposition of residue gas: Used at plants	Returned to formation	Vented or flared	Shipped to transmission companies	Direct deliveries to consumers	Unaccounted for	Total
1967										
Arkansas	1,935	93,452	3,499	4,879	[r]3,232	31	67,065	[r]14,746	---------	89,953
California	23,335	505,063	34,803	28,914	117,382	434	218,890	104,166	474	470,260
Colorado	2,938	112,440	4,126	4,148	9,817	187	93,293	640	229	108,314
Kansas	20,458	1,250,286	30,480	7,613	---------	109	1,172,428	39,746	−90	1,219,806
Kentucky and Illinois	14,402	483,902	25,226	3,502	---------	---------	448,127	6,559	488	458,676
Louisiana	85,697	3,388,334	115,177	52,804	188,564	1,478	2,383,548	616,280	75,488	3,268,157
Michigan	2,552	171,531	3,351	2,344	[r]25,233	---------	[r]140,603	---------	---------	168,180
Mississippi	851	46,068	1,127	1,661	12,938	171	28,585	1,511	75	44,941
Montana and Utah	2,470	60,500	3,377	4,963	14,787	378	36,586	---------	409	57,123
Nebraska	680	13,130	1,170	730	107	77	11,122	---------	−76	11,960
New Mexico	29,697	923,202	46,149	37,052	[r]1,434	5,559	[r]740,960	87,529	4,519	877,053
North Dakota	2,665	42,828	5,150	1,474	4,177	343	30,228	---------	1,456	37,678
Oklahoma	37,489	1,038,103	50,952	48,164	56,531	1,326	775,311	105,041	778	987,151
Pennsylvania	70	2,247	121	14	49	---------	2,063	---------	---------	2,126
Texas	273,358	7,018,237	433,684	312,011	929,381	25,394	4,973,776	329,361	14,630	6,584,553
West Virginia and Florida	9,358	235,832	14,150	1,941	---------	---------	216,929	2,812	---------	221,682
Wyoming	6,500	261,478	11,993	9,957	12,473	450	219,554	6,764	287	249,485
Total	514,455	15,641,633	784,535	522,171	[r]1,326,105	35,937	[r]11,559,068	[r]1,315,155	98,662	14,857,098
1968										
Arkansas	2,188	88,011	3,667	6,204	541	26	58,189	19,288	96	84,344
California	21,992	476,596	32,639	27,471	106,221	330	211,125	97,776	1,034	443,957
Colorado	3,276	96,397	4,546	4,012	6,728	144	80,794	161	12	91,851
Kansas	20,572	1,239,723	29,042	7,499	---------	29	1,154,419	48,782	−48	1,210,681
Kentucky and Illinois	13,802	483,336	22,230	2,411	---------	---------	451,787	6,776	132	461,106
Louisiana	107,098	3,728,717	140,290	61,681	105,778	2,092	2,862,673	555,487	716	3,588,427
Michigan	2,450	156,996	3,244	2,339	19,563	---------	131,850	---------	---------	153,752
Mississippi	977	44,510	971	1,509	11,061	68	29,560	1,209	132	43,539
Montana and Utah	2,849	59,058	4,010	5,025	17,956	852	31,162	---------	53	55,048
Nebraska	604	9,437	794	679	53	24	7,367	---------	520	8,643
New Mexico	32,670	1,058,587	48,635	44,906	1,720	9,820	772,751	175,940	4,815	1,009,952
North Dakota	2,714	41,318	5,428	2,684	7,009	241	24,713	---------	1,243	35,890
Oklahoma	39,402	1,122,692	55,724	48,478	69,746	1,244	826,433	120,287	780	1,066,968
Pennsylvania	64	2,390	116	13	27	---------	2,234	---------	---------	2,274
Texas	286,237	7,239,621	457,117	315,043	896,474	20,558	5,018,815	503,133	28,481	6,782,504
West Virginia and Florida	7,178	210,058	8,034	1,498	48	---------	197,842	2,636	---------	202,024
Wyoming	6,248	259,227	11,390	9,102	13,934	371	211,175	13,935	−680	247,837
Total	550,311	16,316,674	827,877	540,554	1,256,859	35,799	12,072,889	1,545,410	37,286	15,488,797

[r] Revised. [1] 42-gallons.

Table 8.—Estimated proved recoverable reserves of natural gas in the United States as of December 31, 1968

(Million cubic feet at 14.73 psia at 60° F)

State	Nonassociated	Associated-dissolved	Underground storage [1]	Total
Alaska	4,979,055	273,269	------	5,252,324
Arkansas	2,509,768	174,047	31,250	2,715,065
California [2]	3,033,627	4,098,667	184,035	7,316,329
Colorado	1,538,569	102,646	18,888	1,660,103
Illinois	1,301	20,909	275,698	297,908
Indiana	1,731	5,804	67,924	75,459
Kansas	13,994,821	424,037	92,315	14,511,173
Kentucky	818,718	56,426	48,145	923,289
Louisiana [2]	72,264,323	15,661,596	89,705	88,015,624
Michigan	77,274	79,909	600,243	757,426
Minnesota	------	------	64	64
Mississippi	1,139,152	288,668	6,258	1,434,078
Montana	579,572	174,266	157,695	911,533
Nebraska	30,874	10,736	15,158	56,768
New Mexico	11,797,769	3,332,108	13,327	15,143,204
New York	27,477	176	96,434	124,087
North Dakota	4,976	861,834	------	866,810
Ohio	243,344	107,878	432,653	783,875
Oklahoma	14,436,630	3,740,819	190,816	18,368,265
Pennsylvania	844,493	13,979	486,524	1,344,996
Texas [2]	86,489,868	32,420,348	90,892	119,001,108
Utah	687,701	467,756	1,099	1,156,556
Virginia	34,341	------	------	34,341
West Virginia	2,179,581	58,398	347,603	2,585,582
Wyoming	3,249,186	480,369	38,980	3,768,535
Other States [3]	26,148	10,168	209,038	245,354
Total	220,990,299	62,864,813	3,494,744	287,349,856

[1] Gas held in underground reservoirs (including native and net injected gas) for storage.
[2] Includes offshore reserves.
[3] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 9.—Estimated productive capacity of natural gas in the United States, December 31, 1968

(Million cubic feet per day)

State	Productive capacity			State	Productive capacity		
	Non-associated	Associated-dissolved	Total		Non-associated	Associated-dissolved	Total
Alaska	350	78	428	New Mexico	3,707	1,525	5,232
Arkansas	980	95	1,075	New York	14	------	14
California [1]	1,678	1,178	2,856	North Dakota	1	146	147
Colorado	469	73	542	Ohio	90	30	120
Illinois	------	10	10	Oklahoma	9,364	2,843	12,207
Indiana	------	4	4	Pennsylvania	249	4	253
Kansas	9,061	425	9,486	Texas [1]	28,703	11,275	39,978
Kentucky	254	17	271	Utah	142	59	201
Louisiana [1]	25,354	4,534	29,888	Virginia	9	------	9
Michigan	121	60	181	West Virginia	665	18	683
Mississippi	574	79	653	Wyoming	1,157	224	1,381
Montana	171	47	218	Other States [2]	11	4	15
Nebraska	21	12	33				
				Total	83,145	22,740	105,885

[1] Includes offshore.
[2] Includes Alabama, Arizona, Florida, Iowa, Maryland, Missouri, South Dakota, Tennessee, and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 10.—Underground storage statistics, December 31, 1968

(Million cubic feet at 14.73 psia at 60° F)

State	Pools	Wells	Total gas in storage reservoirs	Total reservoir capacity
Arkansas	7	30	12,503	40,182
California	6	159	108,680	288,647
Colorado	3	38	11,040	22,218
Illinois	22	1,065	265,501	526,346
Indiana	25	760	52,475	142,785
Iowa	5	218	118,170	158,992
Kansas	16	745	78,438	105,162
Kentucky	17	781	27,819	61,601
Louisiana	2	49	69,205	104,523
Maryland	1	53	26,011	64,770
Michigan	29	2,072	328,430	694,160
Minnesota	1	16	64	64
Mississippi	2	23	5,757	6,906
Missouri	1	70	25,637	45,000
Montana	6	170	117,957	170,152
Nebraska	1	15	4,099	39,270
New Mexico	3	35	2,419	58,650
New York	15	893	88,209	110,830
Ohio	21	2,686	339,840	502,513
Oklahoma	11	185	173,684	308,922
Pennsylvania	64	2,098	466,792	696,107
Texas	17	164	63,586	113,065
Utah	1	8	1,099	1,447
Washington	1	45	6,763	25,000
West Virginia	35	1,256	325,717	419,553
Wyoming	3	11	26,045	76,628
Total	315	13,645	2,745,940	4,783,493

Source: American Gas Association.

Table 11.—Gas wells and condensate wells in the United States

State	Completed during 1967 [1]	Producing Dec. 31 1967	Completed during 1968 [1]	Producing Dec. 31 1968
Alabama	---------	---------	1	1
Alaska	4	21	7	18
Arizona	2	7	---------	4
Arkansas	70	909	46	947
California	72	1,059	76	994
Colorado	45	827	50	810
Illinois	1	3	1	5
Indiana	5	271	14	265
Kansas	147	8,603	90	8,509
Kentucky	200	6,215	205	6,290
Louisiana	465	9,036	537	9,163
Maryland	---------	13	---------	15
Michigan	26	244	28	199
Mississippi	15	360	12	347
Missouri	---------	11	---------	11
Montana	22	648	40	635
Nebraska	1	37	---------	36
New Mexico	257	8,274	150	8,754
New York	13	1,159	10	1,155
North Dakota	---------	31	---------	19
Ohio	214	3,865	230	4,353
Oklahoma	443	7,726	370	8,337
Pennsylvania	271	17,700	253	17,000
Tennessee	1	21	6	28
Texas	952	23,760	763	23,805
Utah	10	168	5	165
Virginia	---------	104	---------	111
West Virginia	384	20,500	522	18,214
Wyoming	39	749	39	787
Total	3,659	112,321	3,455	110,972

[1] From data compiled by the American Association of Petroleum Geologists and American Petroleum Institute.

Table 12.—Natural gas stored underground in and withdrawn from storage fields

(Million cubic feet at 14.73 psia)

State	1967			1968		
	Total stored	Total withdrawn	Net stored	Total stored	Total withdrawn	Net stored
Alabama	---------	---------	---------	536	509	27
Arkansas	1,317	891	426	1,210	854	356
California	71,148	67,944	3,204	58,085	62,631	—4,546
Colorado	6,391	5,257	1,134	6,849	6,850	—1
Delaware	1,274	980	294	1,500	1,255	245
Illinois	119,125	87,630	31,495	143,180	97,146	46,034
Indiana	25,027	20,236	4,791	26,679	24,906	1,773
Iowa	49,603	36,481	13,122	57,082	54,574	2,508
Kansas	41,661	44,172	—2,511	44,524	41,190	3,334
Kentucky	26,084	23,848	2,236	28,993	28,049	944
Louisiana	47,474	2,745	44,729	33,037	22,799	10,238
Maryland	12,465	3,677	8,788	10,520	6,235	4,285
Massachusetts	293	119	174	769	667	102
Michigan	222,800	229,952	—7,152	255,365	250,874	4,491
Mississippi	4,701	5,177	—476	6,904	6,710	194
Missouri	10,206	10,137	69	8,919	10,167	—1,248
Montana	19,919	6,100	13,819	17,398	8,009	9,389
Nebraska	5,012	4,366	646	2,959	3,764	—805
New Jersey	805	811	—6	975	968	7
New Mexico	383	165	218	74	60	14
New York	42,344	39,616	2,728	44,978	45,482	—504
Ohio	142,717	141,418	1,299	169,955	158,914	11,041
Oklahoma	47,438	20,933	26,505	46,871	36,464	10,407
Pennsylvania	219,010	201,444	17,566	235,415	235,570	—155
Tennessee	---------	---------	---------	2,140	1,906	234
Texas	34,836	23,767	11,069	31,597	34,242	—2,645
Utah	609	389	220	640	611	29
Virginia	158	86	72	272	104	168
Washington	1,270	206	1,064	974	974	---------
West Virginia	159,545	149,030	10,515	181,338	182,982	—1,644
Wyoming	3,748	4,957	—1,209	5,337	4,070	1,267
Total	1,317,363	1,132,534	184,829	1,425,075	1,329,536	95,539

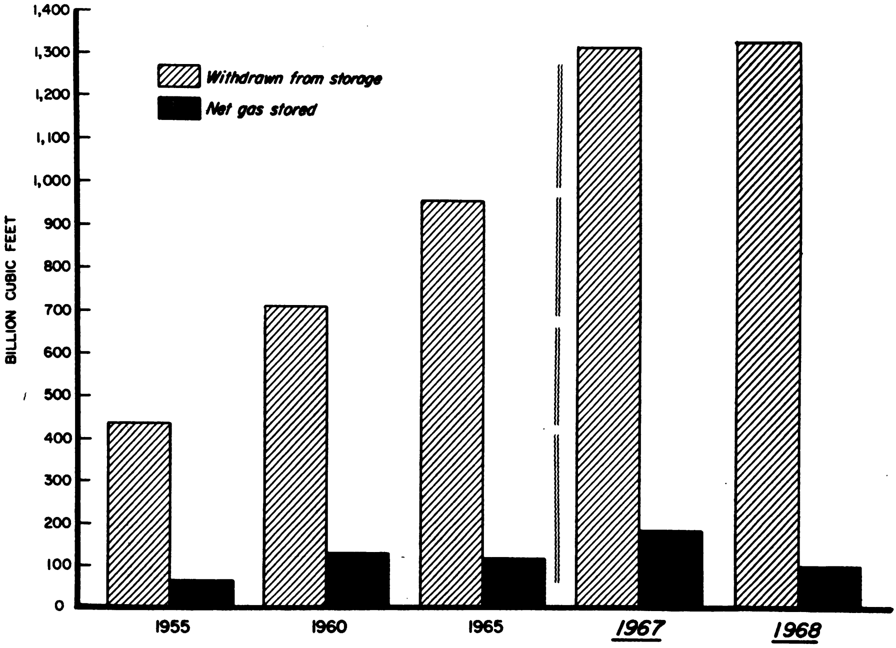

Figure 4.—Trends in net gas stored underground in U.S. storage fields.

Table 13.—Gross withdrawals and disposition of natural gas in the United States

(Million cubic feet at 14.73 psia)

State	Gross withdrawals			Disposition		
	From gas wells	From oil wells	Total [1]	Marketed production	Repressuring	Vented and flared [2]
1967						
Alaska	42,688	23,129	65,817	14,438	39,989	11,390
Arkansas	81,491	46,038	127,529	116,522	10,010	997
California	287,681	573,639	861,320	681,080	176,675	3,565
Colorado	89,866	38,148	128,014	116,857	8,501	2,656
Illinois	[r] 199	[r] 5,071	5,270	5,144	----------	126
Indiana	106	92	198	198	----------	----------
Kansas	730,762	145,591	876,353	871,971	1,752	2,630
Kentucky	88,817	357	89,174	89,168	----------	6
Louisiana	5,070,825	1,016,600	6,087,425	5,716,857	208,719	161,849
Maryland	621	----------	621	621	----------	----------
Michigan	22,709	20,383	43,092	33,589	7,642	1,861
Mississippi	139,608	41,701	181,309	139,497	34,714	7,098
Montana	10,308	21,302	31,610	25,866	722	5,022
Nebraska	6,180	3,902	10,082	8,453	1,629	----------
New Mexico	774,007	301,003	1,075,010	1,067,510	1,508	5,992
New York	3,740	97	3,837	3,837	----------	----------
North Dakota	265	65,992	66,257	40,462	----------	25,795
Ohio	34,291	7,024	41,315	41,315	----------	----------
Oklahoma	1,133,163	488,173	1,621,336	1,412,952	81,755	126,629
Pennsylvania	89,751	590	90,341	89,966	375	----------
Texas	6,280,148	2,011,361	8,291,509	7,188,900	973,206	129,403
Utah	21,685	56,599	78,284	48,965	26,319	3,000
Virginia	3,818	----------	3,818	3,818	----------	----------
West Virginia	209,545	2,545	212,090	211,460	630	----------
Wyoming	221,850	36,115	257,965	240,074	16,393	1,498
Other States [3]	1,298	902	2,200	1,805	35	360
Total	15,345,422	4,906,354	20,251,776	18,171,325	1,590,574	489,877
1968						
Alaska	48,933	50,370	99,303	17,343	57,702	24,258
Arkansas	110,898	51,257	162,155	156,627	4,633	895
California	505,605	311,320	816,925	714,893	99,252	2,780
Colorado	93,556	36,027	129,583	121,424	6,645	1,514
Illinois	183	4,299	4,482	4,380	----------	102
Indiana	234	----------	234	234	----------	----------
Kansas	690,216	149,557	839,773	835,555	1,689	2,529
Kentucky	88,709	330	89,039	89,024	----------	15
Louisiana	5,623,961	1,153,555	6,777,516	6,416,015	195,062	166,439
Maryland	864	----------	864	864	----------	----------
Michigan	24,151	19,779	43,930	40,480	2,330	1,120
Mississippi	136,972	34,645	171,617	135,051	30,656	5,910
Montana	11,208	21,021	32,229	19,313	365	12,551
Nebraska	5,681	3,648	9,329	8,129	1,200	----------
New Mexico	873,211	297,313	1,170,524	1,164,182	355	5,987
New York	4,632	----------	4,632	4,632	----------	----------
North Dakota	225	62,848	63,073	41,023	----------	22,050
Ohio	33,742	8,931	42,673	42,673	----------	----------
Oklahoma	1,225,620	380,957	1,606,577	1,390,884	86,285	129,408
Pennsylvania	87,627	680	88,307	87,987	320	----------
Texas	6,477,441	2,088,647	8,566,088	7,495,414	946,090	124,584
Utah	20,443	58,856	79,299	46,151	30,242	2,906
Virginia	3,389	----------	3,389	3,389	----------	----------
West Virginia	234,361	3,380	237,741	236,971	770	----------
Wyoming	237,156	46,760	283,916	248,481	22,397	13,038
Other States [3]	907	895	1,802	1,281	99	422
Total	16,539,925	4,785,075	21,325,000	19,322,400	1,486,092	516,508

[r] Revised.

[1] Marketed production plus quantities used in repressuring, vented and flared.

[2] Partly estimated; includes direct losses on producing properties and residue blown to the air.

[3] Alabama, Arizona, Florida, Missouri and Tennessee.

Table 14.—Marketed production of natural gas by countries[1] at 60° F (15.56° C) and normal atmospheric pressure[2]

(Million cubic feet)

Country	1964	1965	1966	1967	1968
North America:					
Barbados	94	102	106	[e] 100	97
Canada	1,327,664	1,442,448	1,341,833	1,471,725	1,642,636
Mexico	234,636	249,844	255,128	275,502	285,430
Trinidad and Tobago	38,452	41,456	53,406	51,494	51,594
United States	15,462,143	16,039,753	17,206,628	18,171,325	19,322,400
South America:					
Argentina	[r] 130,996	[r] 153,895	164,282	169,259	188,808
Bolivia	4,145	3,453	3,795	3,503	867
Brazil [e]	[r] 3,100	[r] 4,200	[r] 5,100	6,000	7,000
Chile [e]	[r] 29,000	[r] 30,000	[r] 31,000	33,000	33,500
Colombia	26,919	31,738	35,922	37,721	41,537
Peru	[r] 15,835	[r] 15,446	16,140	[e] 16,500	16,803
Venezuela	237,419	249,815	263,894	292,655	301,200
Europe:					
Austria	62,289	60,872	66,163	63,468	57,562
Czechoslovakia	32,842	30,017	[r] 45,909	[e] 50,000	[e] 50,000
France	179,751	178,268	182,258	196,313	201,293
Germany, West	[r] 61,399	[r] 91,391	[r] 114,182	148,474	[e] 205,000
Hungary [2]	27,702	39,128	54,843	72,218	95,031
Italy	[r] 268,542	[r] 272,910	[r] 296,599	323,671	[e] 360,200
Netherlands	27,015	[r] 55,514	[r] 116,395	253,731	514,172
Poland [2]	41,706	46,333	45,556	55,373	90,264
Rumania	403,186	454,391	497,196	559,525	774,923
U.S.S.R	3,891,658	4,569,696	5,110,008	5,600,880	6,038,690
United Kingdom	200	449	123	16,664	71,335
Yugoslavia	9,676	11,653	14,196	16,313	20,615
Africa:					
Algeria	28,569	[r] 61,544	[r] 72,726	76,226	87,520
Gabon	[r] 334	[r] 376	[r] 405	611	879
Morocco	412	402	389	379	382
Nigeria	1,766	3,531	6,357	5,424	5,190
Tunisia	277	290	296	328	[e] 340
Asia:					
Afghanistan	----------	----------	----------	76	53,000
Bahrain [e]	1,800	1,800	2,000	2,000	2,200
Brunei	6,460	7,870	10,000	[e] 8,000	7,530
India	[e] 5,000	[e] 5,300	[r] 14,126	16,439	21,347
Indonesia [e]	13,000	[r] 15,000	[r] 18,000	22,000	24,066
Iran	42,102	43,423	48,957	51,784	55,534
Iraq	13,500	12,900	21,419	18,191	27,293
Israel	1,069	2,559	3,371	3,859	4,238
Japan	65,640	62,861	64,509	66,734	72,617
Kuwait	57,761	63,356	66,200	[e] 90,000	114,750
Kuwait-Saudi Arabia Neutral Zone [e]	7,500	8,000	8,300	8,500	8,000
Pakistan	59,100	66,194	76,000	83,288	91,525
Qatar	2,789	2,850	[e] 2,900	[e] 3,500	[e] 4,200
Saudi Arabia	36,072	36,331	[e] 40,000	[e] 45,000	[e] 50,000
Taiwan	5,982	10,932	15,507	18,616	24,877
United Arab Republic	1,840	1,720	1,960	[e] 2,000	[e] 2,000
Oceania:					
Australia	106	144	143	152	216
New Zealand	5	5	4	4	3
Total	22,867,453	24,480,160	26,394,231	28,408,525	31,028,664

[e] Estimate. Preliminary. [r] Revised.

[1] Data not available for mainland China and several other countries.

[2] Including gas for repressuring.

NOTE.—The data relate, as far as possible, to natural gas actually collected and utilized as fuel or raw material. They exclude gas used for repressuring (except where otherwise noted), as well as gas flared, vented, or otherwise wasted, whether or not it has first been processed for the extraction of natural gas liquids. Data for countries reporting in cubic meters have been converted using the standard factor of 35.3145 cubic feet per cubic meter.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/83

Natural Gas Liquids

By William B. Harper [1] and Leonard L. Fanelli [2]

Reflecting the continued growth in the production of natural gas to meet demands, the output of natural gas liquids rose to 550.3 million barrels which was 35.8 million barrels or 7 percent larger than that in 1967. The total value of this production, however, declined to $1,124 million which was nearly 55.9 million below the values for 1967. This decline is attributable primarily to a softening of prices for liquefied petroleum gases from $1.94 per barrel to $1.57 per barrel.

Natural gas liquids are products obtained from natural gasoline plants, cycling plants, and fractionators after separating the natural gas. Included in these products are ethane, the liquefied petroleum (LP) gases (butane, propane and butane-propane mixtures), isobutane, and other mixed gases. Also, included in the output of these plants are natural gasolines, plant condensate, and finished products such as gasoline, special naphthas, jet fuel, kerosine, distillate fuel oil, and other finished products.

Shipments from natural gas processing plants of LP gases and ethane totaled 338.8 million barrels, an increase of 12 percent in 1968. Natural gas liquids used as blending material in gasoline totaled 259.3 million barrels, an increase of nearly 6 percent.

These data presented in this chapter are compiled from reports submitted by natural gasoline plants, cycling plants, and fractionators that handle natural gas liquids, and include all natural gas liquids except the small volume recovered at pipeline compressor stations and gas dehydration plants. Such recovery is considered to be of little significance in the national and State totals. Plant condensate is included in the category of natural gas liquids. Field condensate, however, is reported with crude oil and is excluded from the total for natural gas liquids. Liquefied refinery (LR) gases and ethane produced at petroleum refineries are not natural gas liquids, but to obtain complete data on distribution of liquefied gases, tables are included in this chapter covering the production and stocks of LR gases.

Annual reports were received from all producers and distributors and from most of the dealers that sell more than 100,000 gallons of LP gases annually. To reflect total shipments, the sample of dealer shipments was expanded by Petroleum Administration for Defense (PAD) districts on the basis of domestic demand in the districts.

Data on shipments of LP gases, normally reported in this chapter, were not available at the time of publication and will be published in the Mineral Industry Survey "Liquefied Petroleum Gas Shipments, Annuals."

For the purpose of this chapter, liquefied gases and ethane, whether obtained from natural gas or from processing in refineries, are defined as follows:

Ethane.—Includes ethane only. All other LP gases mixed with ethane are reported in their respective product classification.

Propane.—Includes all products covered by Natural Gas Processors Association (NGPA) specifications for commercial propane.

Butane-propane.—Includes all products covered by NGPA specifications for commercial butane propane mixtures.

Butane.—Includes all products covered by NGPA specifications for commercial butane, except those that contain 60 percent or more isobutane.

Isobutane.—Includes all products covered by NGPA specifications for commercial butane that contains 60 percent or more isobutane.

Other Mixtures of Liquefied Petroleum Gases.—Includes mixtures that cannot be classified within the five classifications mentioned, such as mixtures containing less than 50 percent ethane but more than 50 percent propane and butane.

---

[1] Mineral specialist (petroleum), Division of Mineral Studies.
[2] Survey statistician, Division of Statistics.

Isopentane.—Includes segregated isopentane.

Natural Gasoline.—Breakdown by various Reid vapor pressure classifications indicated.

Plant Condensate.—Includes condensate, raw or deenthanized stream.

Gasoline.—Includes all products within the gasoline range for shipment as motor fuel.

Special Naphtha.—Includes all hexanes and heptanes.

Jet Fuel.—Includes all aviation turbine engine fuel for both military and commercial use.

Kerosine.—Includes all grades of kerosine or range oil.

Distillate Fuel Oil.—Includes all light oils for shipment as fuel.

Other Products.—All products not otherwise classified.

Production of natural gas liquids is reported by States, although data for Louisiana and Texas are also reported by districts.

Louisiana is divided into an Inland district and a Gulf Coast district. The Gulf Coast district includes Veron, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, and Washington Parishes (counties), and all parishes in the State south of these. All parishes not included in the Gulf Coast district are in the Inland district.

The Bureau of Mines producing districts in Texas correspond, with one exception, to grouping of the Texas Railroad Commission districts:

Bureau of mines districts	*Railroad Commission districts*
Gulf Coast	Nos. 2 and 3
West Texas	Nos. 7C, 8 and 8A
East Proper	Part of No. 6 (East Texas field in Cherokee, Smith, Upshur, Rush, and Gregg Counties)
Panhandle	No. 10
Rest of State:	
North	Nos. 7B and 9
Central	No. 1
South	No. 4
Other East Texas	Nos. 5 and 6 (exclusive of East Proper)

Refineries are also grouped by the Bureau of Mines into a set of refining districts. These refining districts may be combined to correspond with the Petroleum Administration for Defense districts (PAD districts).

PAD district *Refining district*

1.—*East Coast.*—District of Columbia, Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, Florida, the following counties of New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof, and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York and all counties east thereof.

1.—*Appalachian No. 1*—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.

2.—*Appalachian No. 2*—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.

2.—*Indiana-Illinois-Kentucky*—Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.

2.—*Oklahoma-Kansas-Missouri*—Oklahoma, Kansas, Missouri, Nebraska, and Iowa.

2.—*Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.

3.—*Texas Inland*—Texas, except Texas Gulf Coast district.

3.—*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Galveston, Waller, Fort Bend, Brazoria, Wharton, Harris, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.

3.—*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washing-

PAD district *Refining district*

ton, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George Hancock, Harrison, and Jackson; and Mobile and Baldwin Counties, Alabama.

3.—*North Louisiana-Arkansas*—Arkansas and those parts of Louisiana, Mississippi, and Alabama not included in the Louisiana Gulf Coast District.

3.—*New Mexico*—New Mexico.

4.—*Rocky Mountains*—Montana, Idaho, Wyoming, Utah, and Colorado.

5.—*West Coast*—Washington, Oregon, California, Nevada, Alaska, Arizona, and Hawaii.

Some data in the chapter are based on the Bureau of Mines refining districts, while others refer to the PAD districts. Maps showing the PAD and Bureau of Mines refining districts appear in figure 2 of the Crude Petroleum and Petroleum Products chapter of this volume.

Unlike earlier years, the format and content of table 1 no longer includes supply and demand balances for that part of natural gas liquids relating to the finished petroleum products defined on the first page of this chapter. This is readily understandable as the relative importance of these finished products in terms of volumes and values, is small—only 2 percent of the yield at natural gas processing plants and less than 4 percent of the value.

Finished petroleum products lose their identity as "natural gas liquids" by being absorbed into the supply stream but information on production and on stocks is available in the Minerals Yearbook Chapter, "Crude Petroleum and Petroleum Products" in the table captioned "Salient Statistics of the major refined products in the United States." Also, these data are identified as to origin in table 2 of the Monthly Petroleum Statements and the Annual Petroleum Statements, which are included in the Mineral Industry Surveys published by the Bureau of Mines.

DOMESTIC PRODUCTION

Production of natural gas liquids continued to rise in 1968, along with the expansion in natural gas demand. Production of natural gas liquids and ethane at natural gas processing plants in the United States totaled 550.3 million barrels, an increase of 7 percent over the 514.5 million produced in 1967.

Production of LP gases and ethane rose at a sharper rate than natural gasoline and isopentane. As shown in table 1, production of LP gases and ethane increased to 351 million barrels, which was 24.6 million or 7.5 percent higher than in 1967. A breakdown of the production of natural gas liquids production by volume and value at plants is available in table 2. Table 3 presents detailed description of the production by components in the LP gases group.

A faster growth rate for the output of the LP gases and ethane is readily understandable as processors aim to maximize production of these intermediates as well as the finished products included in table 1.

The production of ethane at natural gas processing plants in 1968 increased to 45.8 million barrels or 24.8 percent above the 1967 level of 36.7 million barrels.

Within the LP gas group, propane production in 1968 was 184.4 million barrels or 8.6 percent above the 1967 results. Propane constitutes 60.4 percent of the overall output of LP gases obtained from gas processing plants.

Butane production in the gas processing plants increased 4.5 percent to 78.9 million barrels in 1968.

Natural gasoline, which accounts for better than a fourth of the entire natural gas liquids output of natural gas processing plants, rose to a new high of 145,214,000 barrels or 6.5 percent in 1968. Table 4 provides production information by vapor pressures for the five PAD districts. Some 63 million barrels of natural gasoline with a vapor pressure of 12 pounds or less, was produced in 1968 and 95 percent of the production was derived from District 3.

In addition to LP gases and ethane produced at gas processing plants, refineries produced more than 118 million barrels of liquefied petroleum gases (known as LRG) in 1968. This production, which is for fuel and chemical use, was 6,570,000 barrels or 5.9 percent larger than in the preceding year. Propane production, including propylene, accounts for better than six out of every ten barrels of LRG produced at refineries. Data on production of LRG are available by type of intermediate and stratified by PAD districts in table 5.

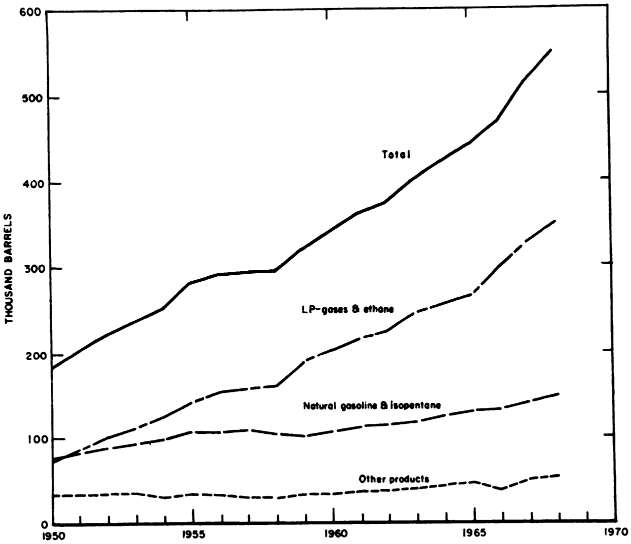

Figure 1.—Production of natural gas liquids in the United States.

RESERVES AND PRODUCTIVE CAPACITY

Proved reserves of natural gas liquids in the United States declined nominally to 8,598 million barrels as of December 31, 1968, according to estimates by the American Gas Association Committee on Natural Gas Reserves. Compared with their 1967 estimate, proved reserves were some 16 million barrels lower at the end of 1968 as shown in table 6.

There were increases in six States including Louisiana and New Mexico, but declines in 16 others, including Texas, more than offset any gains. The principal declines were in California and Texas.

The same American Gas Association Committee also estimated that the productive capacity of natural gas liquids in the United States at the end of 1968 was 3,259,000 barrels per day. Texas, including offshore, accounted for nearly half of the total with 1.5 million barrels per day. Louisiana was second with 901,000 barrels, or 27.6 percent as indicated in table 7.

DEMAND AND USES

Some 259 million barrels of natural gas liquids were shipped to refineries for blending and processing in 1968. This amount was 14.6 million barrels or nearly 6 percent more than that shipped in 1967. Inputs of natural gas liquids in refineries are indicated by months in table 8. Plant condensate used at refineries increased about 1 million barrels to 38.5 million barrels for blending. Conversely, shipments of isopentane to refineries were lower.

Trends were mixed in the use of liquefied petroleum gases at refineries (LRG) as indicated in table 9. There was no discernible trend in uses except for the use of butane in District 4.

Natural gasoline constitutes the largest factor in the natural gas liquids category used at refineries. During 1968, refineries used 145,517,000 barrels of natural gasoline, an increase of 10 million barrels or 7.3 percent above 1967 levels. Demand for natural gasoline exceeded production resulting in a stock reduction for 1968 of 278,000 barrels. Production shipments and stocks of natural gas liquids including natural gasoline are indicated in table 1.

In addition 12,714,000 barrels of other finished products were shipped from the natural gas processing plants during 1968. Gasoline accounted for 6.2 million barrels or 48.8 percent. Production, shipments, etc., are indicated for petroleum products including jet fuel, distillate fuel oil, etc. in table 1.

Domestic demand for LP gases for fuels and chemical use, excluding the quantities used at refineries for blending, rose in 1968 to 267,575,000 barrels, or 14 percent above the 234,523,000 barrels reported for 1967. Propane, which constituted 178,448,000 or two-thirds of the LP gases, experienced an increase of 23.8 million barrels, or 15 percent. Butane demand increased to 40 million barrels or 7.3 percent above the 1967 levels. Ethane demand rose sharply in 1968 to 45,706,000 barrels for an increase of 26.6 percent above the amount used in 1967. Other demand changes in liquefied petroleum gases from the natural gas processing plants and the liquefied refinery gases obtained from refineries, are indicated in table 10.

STOCKS

Part of the softer price structure can be attributed to larger inventories of the LP gases. At the end of 1968, for example, there were 71,140,000 barrels in plant and terminal storage, which was 12.5 million barrels or 21 percent larger than that a year earlier as indicated in table 13. Some 7.5 million barrels of the stock buildup occurred in propane. Stocks of that LP gas at gas processing plants and terminals, as evidenced in table 10, rose from 37,064,000 barrels to 44,523,000, an increase of 20 percent. Inventories of butane increased 2 million barrels during the year or 15 percent.

Isobutane stocks were up to 7,736,000 barrels by yearend as compared with about 5,000,000 barrels at the end of 1967.

The largest market for butane and isobutane is at refineries as these hydrocarbons are used in gasoline blending. Two of the refining processes, hydrocracking and also catalytic reforming, however, yield propane and n-butane and isobutane; hence, as capacity grows so will the production of these natural gas liquids in refineries which include a hydrocracking unit.

At yearend 1968, there were 35 hydrocracking units in operation in the United States with a hydrocracking capacity aggregating nearly 500,000 barrels per stream day.[3]

Underground storage of LP gases at plants and terminals expanded markedly in 1968. By yearend some 57,884,000 barrels, primarily the LP gases, were in underground storage. This volume was 23 million barrels or 66 percent larger than that at yearend 1967. Some 81 percent of the stocks of LP gases at plants and terminals were held in underground storage at the end of 1968.

PRICES AND VALUE

Weaker prices for LP gases resulted in a decline of 4.8 percent in the value of natural gas liquids produced at gas processing plants in 1968. Values aggregated $1,123.8 million which was $56 million or 4.8 percent lower than in 1967. Volumes of LP gases produced were up 7.5 percent in 1968 but softer prices reduced the value of production $81 million or 12.8 percent. The value in dollars per barrel dropped from $1.94 in 1967 to $1.57 in 1968, or 19 percent. The value of natural gasoline and isopentane and other natural gas liquids are shown in table 12.

Prices of LP gases have softened markedly as shown in table 13. In Baton Rouge, La., for example, the price per gallon averaged 4.74 cents in 1968 as compared with 6.24 cents in 1967, or a drop of 24 percent.

FOREIGN TRADE

U.S. imports of butane and propane originate primarily in Canada. In 1968, the United States imported 5,627,000 barrels of propane, which was 34 percent higher than the preceding year. Butane imports increased moderately to 6,020,000 barrels or about 5.6 percent. Mexico continued to be our best export market for natural gas liquids, receiving in 1968 7,677,000 barrels or 72 percent of the total United States exports of 10,602,000 barrels of LP gases.

---

[3] Refers to the throughput or output capacity of a unit operating for a full day with no allowance for "downtime" that is time a unit may be shut down for repairs and maintenance.

Table 1.—Plant production, stocks at plants and terminals, ship

(Thousand

Product	Jan.	Feb.	Mar.	Apr.	May
All products, total:					
Production	45,204	43,509	47,104	45,229	47,005
Stocks	53,528	49,914	52,247	60,160	68,399
Shipments	54,645	47,123	44,771	37,316	38,766
Liquefied petroleum gases (including ethane):					
Production	28,514	27,951	30,362	28,817	29,824
Stocks	49,460	45,367	47,379	55,186	63,233
Shipments	37,739	32,044	28,350	21,010	21,777
Isopentane:					
Production	255	231	235	202	224
Stocks	16	27	10	10	12
Shipments	263	220	252	202	222
Natural gasoline:					
Production	11,712	10,793	11,796	11,677	12,378
Stocks	2,598	2,876	3,058	3,215	3,166
Shipments	11,759	10,515	11,614	11,520	12,427
Plant condensate:					
Production	3,410	3,241	3,342	3,264	3,379
Stocks	915	1,007	1,163	1,262	1,533
Shipments	3,390	3,149	3,186	3,165	3,108
Other products, total:					
Production	1,313	1,293	1,369	1,269	1,200
Stocks	539	637	637	487	455
Shipments	1,494	1,195	1,369	1,419	1,232
Motor gasoline:					
Production	545	505	559	518	508
Stocks	257	249	234	172	127
Shipments	553	513	574	580	553
Special naphthas:					
Production	47	48	47	37	37
Stocks	10	8	9	8	8
Shipments	43	50	46	38	37
Kerosine:					
Production	72	70	84	73	73
Stocks	151	182	202	161	159
Shipments	279	39	64	114	75
Distillate fuel oil:					
Production	24	89	101	97	95
Stocks	20	32	35	33	35
Shipments	33	77	98	99	93
Jet fuel:					
Production	40	37	29	30	40
Stocks	46	53	28	38	44
Shipments	8	30	54	20	34
Miscellaneous products:					
Production	585	544	549	514	447
Stocks	55	113	129	75	82
Shipments	578	486	533	568	440

ments from plants of natural gas processing plant products in 1968

barrels)

June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
							1968	1967
44,497	46,110	45,709	44,570	46,655	46,459	48,260	550,311	514,456
75,182	80,506	86,053	90,155	89,157	83,825	75,296	75,296	62,969
37,714	40,786	40,162	40,468	47,653	51,791	56,789	537,984	489,720
27,504	29,060	28,572	28,584	30,041	30,274	31,759	351,262	326,618
69,857	75,438	80,757	86,057	84,903	79,721	71,140	71,140	58,685
20,880	23,479	23,253	23,284	31,195	35,456	40,340	338,807	302,543
223	225	215	213	210	214	213	2,660	3,021
13	15	14	44	36	36	44	44	24
222	223	216	183	218	214	205	2,640	3,005
12,267	12,810	12,850	12,014	12,580	12,158	12,179	145,214	136,273
3,298	2,959	2,976	2,742	2,754	2,678	2,584	2,584	2,645
12,135	13,149	12,833	12,248	12,568	12,234	12,273	145,275	136,293
3,417	3,241	3,236	2,915	2,957	2,957	3,135	38,494	37,970
1,492	1,578	1,736	737	786	765	841	841	895
3,458	3,155	3,078	3,914	2,908	2,978	3,059	38,548	37,362
1,086	774	836	844	867	856	974	12,681	10,574
522	516	570	575	678	625	687	687	720
1,019	780	782	839	764	909	912	12,714	10,517
498	472	489	498	513	511	595	6,211	7,261
136	147	207	217	321	223	270	270	265
489	461	429	488	409	609	548	6,206	7,364
42	36	35	33	33	38	45	473	51
10	10	11	10	11	9	13	13	6
40	36	34	34	32	35	41	466	51
90	59	104	107	101	97	97	1,027	1,293
220	244	273	241	267	301	290	290	358
29	35	75	139	75	63	108	1,095	1,144
109	76	138	139	152	147	141	1,308	359
32	36	47	46	41	47	65	65	29
112	72	127	140	157	141	123	1,272	366
40	39	5	4	4	4	5	277	44
54	31	7	11	15	19	24	24	14
30	62	29	--------	--------	--------	--------	267	38
307	92	65	63	64	64	91	3,385	1,566
70	48	25	50	23	26	25	25	48
319	114	88	38	91	61	92	3,408	1,554

Table 2.—Natural gas liquids and ethane produced, value at plants in the United States in 1968, by States

(Thousand barrels and thousand dollars)

State	No. of operating companies [1]	LP gases and ethane			Natural gasoline and isopentane			Plant condensate		
		Quantity	Value	Dollars per barrel	Quantity	Value	Dollars per barrel	Quantity	Value	Dollars per barrel
Arkansas	4	1,435	$2,899	2.02	605	$1,779	2.94	91	$248	2.73
California	17	8,589	18,749	2.18	12,828	41,007	3.15	575	1,956	3.40
Colorado	7	1,987	3,338	1.68	1,289	3,248	2.52	----	----	----
Kansas	13	15,748	25,827	1.64	4,618	10,483	2.27	204	488	2.39
Kentucky and Illinois	4	13,032	27,888	2.14	762	2,301	3.02	8	25	3.12
Louisiana	40	57,165	91,464	1.60	28,812	84,370	2.98	11,364	35,797	3.15
Michigan	4	1,384	3,432	2.48	1,051	3,132	2.98	15	45	3.00
Mississippi and Alabama	7	518	958	1.85	401	1,111	2.77	40	121	3.02
Montana and Utah	6	2,060	3,328	1.62	789	2,126	2.69	----	----	----
Nebraska	3	451	911	2.02	153	456	2.98	----	----	----
New Mexico	14	23,802	34,989	1.47	8,643	22,472	2.60	178	486	2.73
North Dakota	3	2,156	3,622	1.68	558	1,479	2.65	----	----	----
Oklahoma	38	25,497	39,520	1.55	12,549	34,761	2.77	1,222	3,690	3.02
Pennsylvania	3	37	95	2.56	27	73	2.69	----	----	----
Texas	80	189,162	278,068	1.47	72,292	194,465	2.69	22,612	67,384	2.98
West Virginia and Florida	5	4,322	10,157	2.35	1,007	2,920	2.90	1,844	3,946	2.14
Wyoming	14	3,917	7,090	1.81	1,990	5,512	2.77	341	989	2.90
Total	143	351,262	552,335	1.57	147,874	411,695	2.78	38,494	115,175	2.99

State	No. of operating companies [1]	Finished gasoline and naphtha			Other products [2]			Total		
		Quantity	Value	Dollars per barrel	Quantity	Value	Dollars per barrel	Quantity	Value	Dollars per barrel
Arkansas	4	----	----	----	57	$165	2.90	2,188	$5,091	2.33
California	17	----	----	----	----	----	----	21,992	61,712	2.81
Colorado	7	----	----	----	----	----	----	3,276	6,586	2.01
Kansas	13	----	----	----	2	6	2.90	20,572	36,804	1.79
Kentucky and Illinois	4	----	----	----	----	----	----	13,802	30,214	2.19
Louisiana	40	5,274	$21,254	4.03	4,978	15,482	3.11	107,093	248,367	2.32
Michigan	4	----	----	----	----	----	----	2,450	6,609	2.70
Mississippi and Alabama	7	----	----	----	18	45	2.52	977	2,235	2.29
Montana and Utah	6	----	----	----	----	----	----	2,849	5,454	1.91
Nebraska	3	----	----	----	----	----	----	604	1,367	2.26
New Mexico	14	----	----	----	47	146	3.11	32,670	58,093	1.78
North Dakota	3	----	----	----	----	----	----	2,714	5,101	1.88
Oklahoma	38	60	166	2.77	74	212	2.86	39,402	78,349	1.99
Pennsylvania	3	----	----	----	----	----	----	64	168	2.63
Texas	80	1,350	5,157	3.82	821	2,176	2.65	286,237	547,250	1.91
West Virginia and Florida	5	----	----	----	----	----	----	7,173	17,023	2.37
Wyoming	14	----	----	----	----	----	----	6,248	13,591	2.18
Total	143	6,684	26,577	3.98	5,997	18,282	3.04	550,311	1,124,014	2.04

[1] A producer operating in more than 1 State is counted once in arriving at U.S. total.

[2] Includes kerosine, jet fuel, distillate fuel, etc.

Table 3.—Production of natural gas liquids and ethane at natural gas processing plants in the United States in 1968

(Thousand barrels)

States by petroleum districts	Liquefied petroleum gas and ethane					Natural gasoline and isopentane	Plant condensate	Finished gasoline and naphtha	All other products [1]	Total
	Propane (including ethane)	Butane	Butane-propane mixture	Isobutane	Total					
District 1:										
Florida and West Virginia	2,928	1,287	---------	107	4,322	1,007	1,844	---------	---------	7,173
Pennsylvania	24	13	---------	---------	37	27	---------	---------	---------	64
Total	2,952	1,300	---------	107	4,359	1,034	1,844	---------	---------	7,237
District 2:										
Illinois and Kentucky	11,805	703	---------	524	13,032	762	8	---------	---------	13,802
Michigan	887	485	---------	12	1,384	1,051	15	---------	---------	2,450
Kansas	10,116	4,545	2	1,085	15,748	4,618	204	---------	2	20,572
Nebraska	270	181	---------	---------	451	153	---------	---------	---------	604
North Dakota	1,326	829	1	---------	2,156	558	---------	---------	---------	2,714
Oklahoma	16,620	6,628	1,006	1,243	25,497	12,549	1,222	60	74	39,402
Total	41,024	13,371	1,009	2,864	58,268	19,691	1,449	60	76	79,544
District 3:										
Alabama and Mississippi	146	120	252	---------	518	401	40	---------	18	977
Arkansas	919	324	1	191	1,435	605	91	---------	57	2,188
Louisiana:										
Gulf	33,643	9,718	204	7,633	51,198	26,848	9,787	2,148	3,341	93,322
Inland	3,590	1,277	500	600	5,967	1,464	1,577	3,126	1,637	13,771
Total	37,233	10,995	704	8,233	57,165	28,312	11,364	5,274	4,978	107,093
New Mexico	13,682	8,238	482	1,400	23,802	8,643	178	---------	47	32,670
Texas:										
Gulf	24,443	4,839	6,388	3,096	38,766	15,090	3,486	282	116	57,740
West	47,098	17,415	856	2,993	68,362	21,964	5,562	---------	13	95,901
East (field)	2,891	1,577	64	20	4,552	1,649	19	---------	19	6,239
Panhandle	14,600	6,383	29	6,074	27,086	10,187	37	---------	56	37,366
Other	33,340	10,673	2,158	4,225	50,396	23,402	13,508	1,068	617	88,991
Total	122,372	40,887	9,495	16,408	189,162	72,292	22,612	1,350	821	286,237
Total	174,352	60,564	10,934	26,232	272,082	110,253	34,285	6,624	5,921	429,165
District 4:										
Colorado	1,270	642	---------	75	1,987	1,289	---------	---------	---------	3,276
Montana and Utah	1,165	801	94	---------	2,060	789	---------	---------	---------	2,849
Wyoming	2,559	1,321	---------	37	3,917	1,990	341	---------	---------	6,248
Total	4,994	2,764	94	112	7,964	4,068	341	---------	---------	12,373
District 5	6,890	904	330	465	8,589	12,828	575	---------	---------	21,992
Total United States	[2] 230,212	78,903	12,367	29,780	351,262	147,874	38,494	6,684	5,997	550,311

[1] Includes jet fuel, kerosine, distillate, and other.

[2] Includes 45,803 thousand barrels of ethane, of which 7,819 thousand barrels was produced in Kentucky and Illinois, 9,410 thousand barrels in Louisiana, and 27,075 thousand barrels in Texas, 20 thousand barrels in Oklahoma, and 1,479 thousand barrels in New Mexico.

Table 4.—Production of natural gasoline by vapor pressure and by PAD districts in the United States in 1968

(Thousand barrels)

Reid vapor pressure	PAD District					Total
	1	2	3	4	5	
12 pounds and less	393	1,885	59,639	739	350	63,006
Over 12 pounds including 14 pounds	616	5,737	14,680	951	178	22,162
Over 14 pounds including 18 pounds	1	4,984	4,287	726	748	10,746
Over 18 pounds including 22 pounds	20	201	418	------	1,813	2,452
Over 22 pounds including 26 pounds	4	939	9,397	683	2,247	13,270
Over 26 pounds	------	5,896	19,221	969	7,492	33,578
Total	1,034	19,642	107,642	4,068	12,828	145,214

Table 5.—Liquefied petroleum gas and ethane (LR gas) produced at refineries for fuel and chemical use in 1968

(Thousand barrels)

States by petroleum district	Propane (including ethane)	Butane	Butane-propane mixture	Total
District 1:				
New Jersey	6,179	951	----------	7,130
Pennsylvania	7,320	17	----------	7,337
Other states [1]	1,406	654	----------	2,060
Total	14,905	1,622	----------	16,527
District 2:				
Illinois	4,746	58	----------	4,804
Indiana	1,270	180	9	1,459
Kansas	3,380	414	1	3,795
Kentucky	598	86	----------	684
Michigan	1,381	63	157	1,601
Ohio	4,038	----------	5	4,043
Oklahoma	3,202	1,693	1,106	6,001
Other States [2]	1,362	78	216	1,656
Total	19,977	2,572	1,494	24,043
District 3:				
Alabama and Mississippi	1,297	----------	39	1,336
Arkansas	682	161	----------	843
Louisiana:				
Gulf	12,157	1,448	3,205	16,810
Inland	251	81	34	366
Total	12,408	1,529	3,239	17,176
New Mexico	137	132	18	287
Texas:				
Gulf	23,741	12,023	3,769	39,533
West	1,056	503	----------	1,559
East	248	----------	----------	248
Panhandle	1,012	527	----------	1,539
Other	138	5	----------	143
Total	26,195	13,058	3,769	43,022
Total	40,719	14,880	7,065	62,664
District 4:				
Colorado	117	142	----------	259
Montana	370	62	18	450
Utah	417	21	----------	438
Wyoming	237	585	14	836
Total	1,141	810	32	1,983
District 5	7,040	3,256	2,574	12,870
Total United States	[3] 83,782	[4] 23,140	11,165	118,087

---

[1] Includes Delaware, New York, Virginia and West Virginia.
[2] Includes Minnesota, Missouri, Nebraska, North Dakota, Tennessee, and Wisconsin.
[3] Includes 9,446 thousand barrels of ethane.
[4] Includes 1,115 thousand barrels of isobutane used for petrochemical feedstock.

Table 6.—Estimated proved recoverable reserves of natural gas liquids[1] in the United States

(Thousand barrels)

State	Reserves as of Dec. 31, 1967	Changes in reserves during 1968: Extensions and revisions[2]	Changes in reserves during 1968: Discoveries of new fields and new pools	Changes in reserves during 1968: Net-production	Reserves as of Dec. 31, 1968: Non-associated with oil	Reserves as of Dec. 31, 1968: Associated-dissolved	Reserves as of Dec. 31, 1968: Total
Arkansas	14,574	---------	---------	1,478	8,605	4,491	13,096
California[3]	218,602	7,305	---------	22,639	8,680	194,588	203,268
Colorado	22,920	2,009	160	2,488	5,705	16,896	22,601
Illinois	2,298	(13)	---------	390	3	1,892	1,895
Indiana	59	(5)	---------	10	9	35	44
Kansas	271,952	15,879	197	17,472	261,153	9,403	270,556
Kentucky	51,638	2,809	1,405	3,388	52,464	---------	52,464
Louisiana	2,607,188	252,110	24,144	215,922	2,228,841	438,679	2,667,520
Michigan	3,544	1,323	60	1,335	1,429	2,163	3,592
Mississippi	17,312	2,392	2,073	2,199	12,576	7,002	19,578
Montana	9,756	778	---------	751	1,950	7,833	9,783
Nebraska	2,266	446	---------	627	713	1,372	2,085
New Mexico	555,702	94,827	367	46,733	387,305	216,858	604,163
North Dakota	64,277	---------	---------	2,714	---------	61,563	61,563
Ohio	582	---------	---------	59	---------	523	523
Oklahoma	455,753	28,040	4,371	40,141	305,936	142,087	448,023
Pennsylvania	1,162	---------	---------	98	1,064	---------	1,064
Texas	4,102,995	205,226	23,354	326,202	2,285,959	1,719,414	4,005,373
Utah	42,748	99	---------	2,352	852	39,643	40,495
West Virginia	81,662	5,886	2,943	6,864	83,627	---------	83,627
Wyoming	87,241	5,518	75	7,866	45,250	39,718	84,968
Miscellaneous[4]	---------	1,000	881	54	880	947	1,827
Total	8,614,231	625,629	60,030	701,782	5,693,001	2,905,107	8,598,108

[1] Comprises natural gasoline, LP-gases, and condensate.

[2] Parenthesis denotes decrease.

[3] Includes offshore reserves.

[4] Includes Alabama.

Total remaining recoverable Natural Gas Liquids reserves in the Gulf of Mexico are estimated to be 847,196,000 bbls.; of which 758,000 bbls. are Non-Associated and 88,382,000 bbls. are Associated-Dissolved.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 7.—Estimated productive capacity of natural gas liquids in the United States, December 31, 1968

(Thousand barrels per day)

State	Productive capacity[1]: Non-associated	Productive capacity[1]: Associated or dissolved	Productive capacity[1]: Total
Arkansas	4	2	6
California[2]	4	69	73
Colorado	2	6	8
Illinois	-------	1	1
Kansas	182	11	193
Kentucky	10	-------	10
Louisiana[2]	789	112	901
Michigan	3	2	5
Mississippi	5	4	9
Montana	1	2	3
Nebraska	1	1	2
New Mexico	105	83	188
North Dakota	-------	8	8
Oklahoma	178	88	266
Texas[2]	929	599	1,528
Utah	-------	7	7
West Virginia	21	-------	21
Wyoming	20	9	29
Miscellaneous[3]	1	-------	1
Total	2,255	1,004	3,259

[1] The productive capacity of natural gas liquids is defined as the amount of hydrocarbon liquids that would be produced coincident with the estimated productive capacity of natural gas based on unit recoveries at normal producing rates. Such estimated capacities are not limited by lack of capacity of processing plants or other surface facilities and it is emphasized that adequate facilities would be required to effect the recovery of liquids from the natural gas produced at these rates. It should also be recognized that such facilities cannot be enlarged quickly. Therefore, the estimated natural gas liquid capacities, which relate to increased production of gas from oil and gas wells operating at their productive capacities, are theoretical. In the event of an emergency requiring capacity production of hydrocarbon liquids, both oil and natural gas liquids, the capacities of existing processing plants would limit the amount of natural gas liquid capacity realized.

[2] Includes offshore.

[3] Includes Alabama, Arizona, Florida, Iowa, Maryland, Minnesota, Missouri, South Dakota, Tennessee and Washington.

Source: Committee on Natural Gas Reserves, American Gas Association.

Table 8.—Natural gas liquids used as refinery input in the United States in 1968, by Bureau of Mines refinery districts, and by months

(Thousand barrels)

District	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
East Coast	416	304	302	333	276	362	309	361	564	642	725	778	5,372
Appalachian	29	29	12	10	19	23	16	11	16	10	16	12	203
Indiana, Illinois, Kentucky, etc	2,357	1,873	1,709	1,278	1,428	1,583	1,606	1,738	1,733	2,086	2,179	2,260	21,830
Minnesota, Wisconsin, North Dakota, and South Dakota	271	241	223	185	138	186	223	249	346	388	452	463	3,365
Oklahoma, Kansas, Missouri	1,736	1,462	1,469	1,433	1,528	1,529	1,513	1,667	1,722	1,966	1,840	2,021	19,886
Texas:													
Inland	1,891	1,738	1,804	1,751	1,897	1,927	2,001	2,037	1,873	2,001	1,746	1,862	22,528
Gulf Coast	10,023	8,636	9,121	9,689	9,729	9,981	9,466	10,124	10,712	10,011	10,612	10,044	118,148
Total	11,914	10,374	10,925	11,440	11,626	11,908	11,467	12,161	12,585	12,012	12,358	11,906	140,676
Louisiana-Arkansas:													
Louisiana Gulf Coast	2,617	2,123	2,311	2,397	2,677	2,181	2,675	2,868	2,513	2,737	2,884	3,475	31,458
Arkansas and Louisiana Inland	406	430	432	411	454	448	464	465	384	455	485	481	5,315
Total	3,023	2,553	2,743	2,808	3,131	2,629	3,139	3,333	2,897	3,192	3,369	3,956	36,773
New Mexico	80	84	75	70	77	105	106	116	105	101	87	75	1,081
Other Rocky Mountain	470	425	420	418	434	433	463	462	431	505	497	525	5,483
West Coast	2,195	1,883	1,965	2,015	1,986	1,774	2,079	1,946	2,180	2,332	2,285	2,027	24,667
Total United States	22,491	19,228	19,843	19,990	20,643	20,532	20,921	22,044	22,579	23,234	23,808	24,023	259,336

Table 9.—Refinery input of LPG by product and PAD district

(Thousand barrels)

LPG product	PAD District					United States
	1	2	3	4	5	
1966						
Propane	------	7	648	109	1,894	2,658
Butane	1,841	13,015	17,822	1,479	3,954	38,111
Isobutane	121	4,556	18,178	871	896	24,622
Butane-propane mix	------	1,885	793	--------	334	3,012
Total	1,962	19,463	37,441	2,459	7,078	68,403
1967						
Propane	------	5	838	90	1,083	2,016
Butane	2,040	13,858	14,628	1,658	5,336	37,520
Isobutane	79	4,800	20,437	678	662	26,656
Butane-propane mix	------	1,947	144	154	238	2,483
Total	2,119	20,610	36,047	2,580	7,319	68,675
1968						
Propane	------	3	575	10	999	1,587
Butane	1,992	14,322	17,882	2,097	5,203	41,496
Isobutane	92	4,775	20,418	434	1,349	27,068
Butane-propane mix	------	1,792	35	403	271	2,501
Total	2,084	20,892	38,910	2,944	7,822	72,652

Table 10.—Production, stocks, and demand of liquefied gases and ethane at gas processing plants and refineries

(Thousand barrels)

	Ethane		Propane		Butane		Butane-propane mixtures		Isobutane		Total	
	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968	1967	1968
Production:												
At gas processing plants (LPG)	36,733	45,803	169,767	184,409	75,492	78,903	15,433	12,367	29,193	29,780	326,618	351,262
At refineries:												
For fuel use (LRG)	-------	-------	53,689	56,847	10,147	9,584	3,753	4,671	-------	-------	67,589	71,102
For chemical use (LRG)	7,028	9,446	18,444	17,489	10,089	12,441	7,022	6,494	1,345	1,115	43,928	46,985
Total	43,761	55,249	241,900	258,745	95,728	100,928	26,208	23,532	30,538	30,895	438,135	469,349
Net change in stocks:												
Liquefied petroleum gases:												
At gas processing plants (LPG)	644	97	15,493	7,459	7,864	2,084	−124	115	698	2,700	24,075	12,455
At refineries (LRG)	-------	-------	−2	-------	2	65	39	−41	−71	68	−32	92
Liquefied refinery gases:												
For fuel use (LRG)	-------	-------	1,103	−498	410	−201	98	183	-------	-------	1,611	−516
For chemical use (LRG)	-------	-------	−8	10	−12	−37	-------	1	−2	−10	−22	−36
Imports	-------	-------	4,190	5,627	5,695	6,020	-------	-------	-------	-------	9,885	11,647
Exports	-------	-------	1,782	2,542	914	1,183	6,566	6,883	-------	-------	9,262	10,608
Used at refineries	-------	-------	2,040	1,587	35,586	41,526	2,483	2,527	28,566	27,012	68,675	72,652
Domestic demand:												
At gas processing plants (LPG)[1]	36,089	45,706	154,644	178,448	37,321	40,065	6,469	3,356	-------	-------	234,523	267,575
At refineries:												
For fuel use (LRG)	-------	-------	52,586	57,845	9,737	9,785	3,655	4,488	-------	-------	65,978	71,618
For chemical use (LRG)	7,028	9,446	18,452	17,479	10,101	12,478	7,022	6,020	1,347	1,125	43,950	46,548
Total	43,117	55,152	225,682	253,272	57,159	62,328	17,146	13,864	1,347	1,125	344,451	385,741
Stocks:												
Liquefied petroleum gases:												
At gas processing plants (LPG)	2,115	2,212	37,064	44,523	14,057	16,141	413	528	5,036	7,736	58,685	71,140
At refineries (LRG)	-------	-------	5	5	292	357	53	12	205	273	555	647
Liquefied refinery gases:												
For fuel use (LRG)	-------	-------	3,445	2,947	1,137	936	159	342	-------	-------	4,741	4,225
For chemical use (LRG)	-------	-------	63	73	79	42	-------	1	42	32	184	148
Total	2,115	2,212	40,577	47,548	15,565	17,476	625	883	5,283	8,041	64,165	76,160

[1] For fuel and chemical use.

Table 11.—Stocks of natural gas liquids and ethane in the United States

(Thousand barrels)

Date	LP gases and ethane		Natural gasoline and isopentane		Other finished products and plant condensate		Total at plants and terminals	Total at refineries	Grand total
	At plants and terminals	At refineries	At plants and terminals	At refineries	At plants and terminals	At refineries			
Dec. 31:									
1964	28,708	904	2,362	1,996	1,354	354	32,424	3,254	35,678
1965	29,416	587	3,116	1,629	952	166	33,484	2,382	35,866
1966	34,610	587	2,673	1,300	950	303	38,233	2,190	40,423
1967	58,685	555	2,669	2,077	1,615	141	62,969	2,773	65,742
1968:									
Jan. 31	49,460	503	2,614	1,982	1,454	141	53,528	2,626	56,154
Feb. 28	45,367	542	2,903	2,369	1,644	188	49,914	3,099	53,013
Mar. 31	47,379	557	3,068	2,813	1,800	194	52,247	3,564	55,811
Apr. 30	55,186	605	3,225	2,190	1,749	243	60,160	3,038	63,198
May 31	63,233	691	3,178	1,767	1,988	249	68,399	2,707	71,106
June 30	69,857	616	3,311	1,484	2,014	248	75,182	2,348	77,530
July 31	75,438	598	2,974	2,055	2,094	233	80,506	2,886	83,392
Aug. 31	80,757	597	2,990	1,947	2,306	211	86,053	2,755	88,808
Sept. 30	86,057	534	2,786	1,781	1,312	208	90,155	2,523	92,678
Oct. 31	84,903	502	2,790	1,732	1,464	240	89,157	2,474	91,631
Nov. 30	79,721	597	2,714	1,619	1,390	192	83,825	2,408	86,233
Dec. 31	[1] 71,140	647	2,628	1,860	1,528	137	75,296	2,644	77,940

[1] Includes 57,884 thousand barrels in underground storage.

Table 12.—Values and volumes of natural gas liquids and ethane produced in the United States

	Thousand barrels		Percent change	Thousand dollars		Percent change	Dollars per barrel		Percent change
	1967	1968		1967	1968		1967	1968	
LP gases and ethane	326,618	351,262	+7.5	632,994	552,200	−12.8	1.94	1.57	−19.1
Natural gasoline and isopentane	139,294	147,874	+6.2	389,156	411,589	+5.8	2.79	2.78	−0.4
Plant condensate	37,970	38,494	+1.4	119,943	115,175	−4.0	3.16	2.99	−5.4
Finished gasoline and naphthas	7,312	6,684	−8.6	28,044	26,577	−5.2	3.84	3.98	+3.6
Other products	3,262	5,997	+83.8	9,799	18,232	+86.1	3.00	3.04	+1.3
Total	514,456	550,311	+7.0	1,179,936	1,123,773	−4.8	2.29	2.04	−10.9

Table 13.—Average monthly prices, liquefied petroleum gas (propane) in the United States[1]

(Cents per gallon)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average for year
New York Harbor:													
1967	9.21	9.25	9.25	9.25	9.25	9.10	8.75	8.75	8.75	8.75	8.75	8.75	8.98
1968	8.75	8.75	8.48	8.00	7.29	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.67
Oklahoma:													
1967	5.94	6.00	6.00	6.00	6.00	5.87	5.75	5.57	5.75	5.75	5.75	5.73	5.86
1968	5.69	5.49	4.68	4.13	3.77	3.75	3.75	3.75	3.75	3.75	3.75	4.05	4.19
Baton Rouge:													
1967	6.19	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.24
1968	6.25	6.11	5.39	4.75	4.34	4.25	4.25	4.25	4.25	4.25	4.25	4.55	4.74

[1] Producers' net contract prices (after some discounts and summer-fill allowances) for propane, tank cars/transport trucks.

Source: Platt's Oil Price Handbook.

Table 14.—LP gases[1] exported from the United States, by countries

(Thousand barrels and thousand dollars)

Country	1967				1968			
	Butane	Propane	Butane-propane mixtures	Total	Butane	Propane	Butane-propane mixtures	Total
Argentina	(2)	79	(2)	79	225	237	-------	462
Bahamas	6	[r] 42	-------	48	(2)	54	(2)	54
Belgium-Luxembourg	(2)	(2)	23	23	4	7	14	25
Brazil	67	11	-------	78	377	------	(2)	377
Canada	229	22	112	363	277	17	116	410
Chile	------	------	-------	-------	(2)	22	26	48
France	(2)	------	(2)	(2)	(2)	114	(2)	114
Guatemala	------	(2)	27	27	3	------	11	14
Japan	(2)	------	6	6	(2)	------	1	1
Mexico	427	766	6,358	7,551	245	731	6,701	7,677
Netherlands	(2)	------	29	29	(2)	(2)	(2)	(2)
United Kingdom	177	847	1	1,025	1	1,343	1	1,345
Other	5	10	11	26	48	15	12	75
Total	911	[r] 1,777	6,567	9,255	1,180	2,540	6,882	10,602
Total value	$3,626	$7,090	$21,466	$32,182	$3,325	$9,865	$19,298	$32,488

[r] Revised.
[1] Data include LR gases.
[2] Less than ½ unit.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/75

Nickel

By Gilbert L. DeHuff[1]

The supply of nickel remained tight in 1968 and the principal domestic suppliers were under Government order to set aside a percentage of their monthly shipments for defense-rated orders. The nickel available for general consumption was allotted to customers worldwide on the basis of past deliveries, and there were no releases from U.S. Government stocks other than some deliveries made on old contracts. As a result, some consumers—particularly electroplaters and foundries—were forced to buy at premium prices in order to meet their needs. Consumption decreased and producers attributed it in part to the scarce supply. Exploration and development of nickel deposits was energetically pursued throughout the world, while the existing large producers increased their output.

Legislation and Government Programs.—As of December 31, 1968, the total nickel stockpile inventory was 70,684 short tons (69,304 tons in the national stockpile, plus 1,380 tons of Defense Production Act stocks), compared with 73,828 tons at the end of 1967 (69,536 tons in the national stockpile, plus 4,292 tons of Defense Production Act stocks). There were no sales of Government nickel stocks in 1968, and the 3,144-ton difference in inventories represents the deliveries made on previously existing contracts. The stockpile objective was unchanged at 20,000 tons.

To assure a sufficient supply of nickel for defense needs, the Business and Defense Services Administration, Department of Commerce, in each of the last 9 months of the year, ordered the three principal U.S. suppliers—The International Nickel Co., Inc., The Hanna Mining Co., and Kaiser-Le Nickel Co.—to set aside 25 percent of their average monthly shipments, based on those made in the second half of 1967, for defense-rated orders. This was an increase from the 23 percent set aside in February and March, and the 20 percent set aside in January, based on an earlier period.

Table 1.—Salient nickel statistics

(Short tons)

	1964	1965	1966	1967	1968
United States:					
Mine production	15,420	16,188	15,036	15,287	17,294
Plant production:					
Primary	12,185	13,510	13,237	14,615	15,154
Secondary	23,114	19,407	26,777	20,731	14,061
Exports	68,502	20,935	26,387	31,587	33,681
Imports for consumption	129,000	163,000	141,000	143,000	147,950
Consumption	146,920	172,084	187,833	173,798	159,306
Stocks Dec. 31, consumer	17,185	14,047	31,288	31,007	26,534
Price cents per pound	79	79–77¾	77¾–85¼	85¼–94	94–103
World: Production	408,929	468,347	454,912	485,723	528,563

DOMESTIC PRODUCTION

Domestic production of nickel ore consisted entirely of 1,217,906 dry short tons of lateritic ore from the Nickel Mountain open-pit mine of The Hanna Mining Co. at Riddle, Douglas County, Oreg. This ore contained 17,294 tons of nickel, and was delivered to the nearby Hanna smelter which produced 25,835 tons of ferronickel, containing 13,124 tons of nickel. Copper and other metal refining plants recovered byproduct nickel as nickel sulfate, largely from materials of foreign origin.

---

[1] Physical scientist, Division of Mineral Studies.

The International Nickel Co., Inc. (Inco), continued its exploratory work in the Duluth gabbro (see Technology) near Ely, Minn., with average nickel content proving less than expected in some areas. A deep shaft was sunk for the purpose of obtaining information to estimate probable mining costs and to obtain bulk samples for metallurgical testing.

The Anaconda Company reported that exploratory drilling had disclosed large tonnages of nickel-copper values in the Stillwater district near Nye, Mont. The favorable mineralization, nickel dominant with copper subordinate, lies close to the surface within a 12-mile strike length along the Stillwater igneous complex. Open-pit mining can be employed. Combined nickel-copper values were said to be the equivalent of approximately 1 percent copper ore, and good recoveries of both nickel and copper were obtained in metallurgical tests. Four diamond drills, together with bulldozers, were engaged in the program.

Basic Inc., Cleveland, Ohio, was investigating a nickel-copper-cobalt sulfide deposit in Maine. The company reported that concentrates of commercial grade were obtained from pilot plant tests. Further investigation was needed to determine the size of the ore body and to estimate costs.

Table 2.—Primary nickel produced in the United States

(Short tons, nickel content)

	1964	1965	1966	1967	1968
Byproduct of metal refining	949	844	1,006	1,579	2,030
Domestic ore	11,236	12,666	12,231	13,036	13,124

Table 3.—Nickel recovered from nonferrous scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1967	1968	Form of recovery	1967	1968
New scrap:			As metal	2,393	1,165
Nickel-base	1,457	1,733	In nickel-base alloys	2,688	2,006
Copper-base	6,334	2,828	In copper-base alloys	7,810	5,217
Aluminum-base	540	600	In aluminum-base alloys	885	1,050
Total	8,331	5,161	In ferrous and high-temperature alloys [1]	6,019	4,172
Old scrap:			In chemical compounds	936	451
Nickel-base	11,260	7,802	Total	20,731	14,061
Copper-base	840	748			
Aluminum-base	300	350			
Total	12,400	8,900			
Grand total	20,731	14,061			

[1] Includes only nonferrous nickel scrap added to ferrous and high-temperature alloys.

CONSUMPTION AND USES

U.S. consumption of nickel, exclusive of scrap, decreased in 1968, with the greatest tonnage drop occurring in the use for stainless steels. The American Iron and Steel Institute's production figures for 1967 and 1968 showed that not only did the output of stainless steels with high nickel content decrease, but total output of nickel-bearing stainless decreased as well. This was coupled with a 28-percent increase in production of the 200 series—those stainless steels in which manganese substitutes for much of the nickel that would otherwise be required.

Table 4.—Stocks and consumption of new and old nickel scrap in the United States in 1968

(Gross weight, short tons)

Class of consumer and type of scrap	Stocks beginning of year	Receipts	Consumption			Stocks, end of year
			New	Old	Total	
Smelters and refiners:						
Unalloyed nickel	109	1,594	1,228	367	1,595	108
Monel metal	429	2,014	344	1,592	1,936	507
Nickel silver [1]	966	5,089	715	4,678	5,393	662
Miscellaneous nickel alloys	6	5,093	106	4,993	5,099	--------
Nickel residues	75	122	--------	176	176	21
Total	619	8,823	1,678	7,128	8,806	636
Foundries and plants of other manufacturers:						
Unalloyed nickel	152	5,058	59	4,757	4,816	394
Monel metal	19	225	78	156	234	10
Nickel silver [1]	9,523	9,929	12,243	150	12,393	7,059
Miscellaneous nickel alloys	--------	--------	--------	--------	--------	--------
Nickel residues	345	587	278	319	597	335
Total	516	5,870	415	5,232	5,647	739
Grand total:						
Unalloyed nickel	261	6,652	1,287	5,124	6,411	502
Monel metal	448	2,239	422	1,748	2,170	517
Nickel silver [1]	10,489	15,018	12,958	4,828	17,786	7,721
Miscellaneous nickel alloys	6	5,093	106	4,993	5,099	--------
Nickel residues	420	709	278	495	773	356
Total	1,135	14,693	2,093	12,360	14,453	1,375

[1] Excluded from totals because it is copper-base scrap, although containing considerable nickel.

Table 5.—Nickel (exclusive of scrap) consumed in the United States, by form

(Short tons)

Form	1964	1965	1966	1967 [1]	1968 [1]
Metal	123,443	146,357	132,573	124,639	115,839
Ferronickel	---------	---------	29,674	25,228	15,170
Oxide powder and oxide sinter	21,090	23,047	22,845	19,349	24,362
Matte	2	3	---------	---------	---------
Salts [2]	2,385	2,677	2,741	4,582	3,935
Total	146,920	172,084	187,833	173,798	159,306

[1] Metallic nickel and nickel salts consumed by plating industry are estimated.
[2] Figures do not cover all consumers for 1964 through 1966.

Table 6.—Nickel (exclusive of scrap) consumed in the United States, by use

(Short tons)

Use	1964	1965	1966	1967 [1]	1968 [1]
Alloy steels:					
Wrought	24,679	27,009	27,807	18,780	16,695
Cast				4,881	5,997
Cast irons	6,605	6,937	7,286	6,596	6,322
Copper-base alloys:					
Wrought (including coinage)	--------	--------	[2] 9,937	4,555	1,987
Cast				3,853	2,976
Electrical resistance alloys [3]	15,291	18,464	5,423	4,311	3,886
Electroplating:					
Anodes [4]	19,446	19,450	13,828	23,721	21,911
Solutions	1,645	2,037	1,925	4,041	3,522
Nickel alloys:					
Wrought	23,639	37,082	[2] 47,366	38,992	34,814
Cast				4,217	7,271
Permanent magnets	664	828	807	896	748
Stainless and heat-resisting steels:					
Wrought	48,301	51,700	65,910	38,882	29,083
Cast				14,054	15,775
Other [5]	6,650	8,577	7,544	6,019	8,319

[1] Metallic nickel and nickel salts consumed by the plating industry are estimated.
[2] Copper-base and nickel alloys formerly published together as nonferrous.
[3] Before 1966, included high temperature alloy; thereafter shown under nickel alloy.
[4] Includes metallic nickel used in baskets.
[5] Catalysts, ceramics, chemicals (other than electroplating), iron-nickel alloys.

Table 7.—Consumer stocks of nickel (exclusive of scrap) in the United States, by form

(Short tons)

Form	1966	1967 [r]	1968
Metal	20,963	24,383	19,296
Ferronickel	5,819	2,462	2,513
Oxide powder and oxide sinter	4,118	3,759	4,400
Salts	388	403	325
Total	31,288	31,007	26,534

[r] Revised.

PRICES

The producer price for nickel cathodes was increased 9 cents at the end of December to $1.03 per pound, f.o.b. shipping point, having remained at 94 cents per pound since the last quarter of 1967. The Hanna Mining Co. followed this action by increasing its price for ferronickel the same amount to $1.005 per pound of contained nickel, f.o.b. shipping point. Other primary nickel producers made similar increases in the prices of their principal products. Metals Week continued to quote prices for merchants', or dealer, cathodes at $1.95 to $2.05 per pound, delivered, into April. These quotes then dropped until they reached $1.55 to $1.65 in September, increasing to $1.65–$1.75 in the middle of December.

FOREIGN TRADE

The bulk of nickel imports continued to come from Canada. Of the ferronickel imported into the United States in 1968, totaling 10,558 short tons, 8,718 tons came from New Caledonia, 1,034 tons from Greece, 588 tons from the Dominican Republic, and the remainder from Australia, the Republic of South Africa, the United Kingdom, and Canada, in decreasing order of magnitude. In 1967, all of the imported ferronickel was from New Caledonia, except for small quantities of less than 6 tons each from the Domician Republic, the United Kingdom, and West Germany. In 1966 Canada supplied 41 tons and the United Kingdom 1 ton, with all of the large remainder from New Caledonia.

Effective June 7, 1968, under the provisions of the Cuban Assets Control Regulations (31 CFR Part 515), the Office of Foreign Assets Control, Department of the Treasury, prohibited entry of certain nickel-bearing materials from Italy unless certified by the Italian Government to contain no Cuban nickel. Stainless steel rods and bars were the principal items affected.

Table 8.—U.S. exports of nickel and nickel alloy products, by class

Class	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Unwrought	11,456	$17,592	7,453	$14,347	6,498	$14,211
Bars, rods, angles, shapes, and sections	2,828	8,689	2,595	8,697	2,880	7,277
Plates, sheets, and strip	1,104	5,718	1,997	9,292	2,308	9,784
Anodes	194	403	232	558	107	326
Wire	475	2,203	565	2,530	624	2,652
Powder and flakes	334	1,376	533	2,144	337	1,598
Foil	13	71	6	26	51	92
Catalysts	3,135	6,589	3,441	9,387	3,340	7,299
Tubes, pipes, blanks, and fittings therefor, and hollow bars	972	3,214	823	3,417	774	3,646
Waste and scrap	5,876	6,229	13,892	20,331	16,762	24,788
Total	26,387	52,084	31,537	70,729	33,681	71,673

Table 9.—U.S. imports for consumption of nickel products, by class

Class	1966 Short tons	1966 Value (thousands)	1967 Short tons	1967 Value (thousands)	1968 Short tons	1968 Value (thousands)
Ore	(1)	$11	---------	---------	42	$2
Unwrought	112,886	170,806	113,860	$193,848	108,158	201,812
Oxide and oxide sinter	7,711	7,967	6,208	8,130	6,388	8,911
Slurry [2]	20,400	26,359	r 22,984	39,892	35,099	68,674
Bars, plates, sheets	r 130	519	r 172	536	245	669
Rods and wire	340	1,140	428	1,435	392	1,287
Shapes, sections, and angles	1	7	1	1	---------	---------
Pipes, tubes, and fittings	14	43	107	442	146	627
Powder	4,123	7,195	3,716	7,319	2,936	6,106
Flakes	18	28	(1)	(1)	53	109
Waste and scrap	941	709	1,104	1,240	1,969	2,564
Ferronickel	11,898	4,519	9,020	3,482	10,558	5,461
Total (gross weight)	r 158,462	219,303	r 157,600	256,325	165,986	290,722
Nickel content (estimated)	141,000	XX	143,000	XX	147,950	XX

r Revised. XX Not applicable.

[1] Less than ½ unit.

[2] Nickel-containing material in powder, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.

Table 10.—U.S. imports for consumption of new nickel products,[1] by country

(Short tons)

Country	Metal 1967 (Gross weight)	Metal 1968 (Gross weight)	Oxide and oxide sinter 1967 (Gross weight)	Oxide and oxide sinter 1968 (Gross weight)	Slurry and other [2] 1967 Gross weight	Slurry and other [2] 1967 Nickel content	Slurry and other [2] 1968 Gross weight	Slurry and other [2] 1968 Nickel content
Canada	104,157	97,101	6,208	6,383	19,899	16,594	31,921	26,363
Finland	114	26	------	------	------	------	------	------
France	66	33	------	1	------	------	------	------
Germany, West	53	10	(3)	------	------	------	------	------
Netherlands	85	27	------	------	r 22	r 4	------	------
Norway	8,516	9,518	------	------	------	------	------	------
South Africa, Republic of	272	239	------	------	3,063	1,413	3,178	1,443
Sweden	11	116	------	------	------	------	------	------
U.S.S.R	176	403	------	------	------	------	------	------
United Kingdom	398	681	(3)	4	------	------	------	------
Other countries	12	4	------	------	------	------	------	------
Total	113,860	108,158	6,208	6,388	r 22,984	r 18,011	35,099	27,806

r Revised.

[1] Ore: 1967, no transactions; 1968, 42 short tons from Japan.

[2] Nickel-containing material in powder, slurry, or any form, derived from ore by chemical, physical, or any other means, and requiring further processing to recover nickel or other metals.

[3] Less than ½ unit.

WORLD REVIEW

Australia.—Western Mining Corp. was the only nickel producer, but many mining organizations, including that company, pursued exploratory and developmental activities. Western Mining's reserves in the Kambalda-St. Ives area, south of Kalgoorlie, Western Australia, were increased to 14.3 million tons of ore, averaging 3.4 percent nickel. The company started construction of a $33 million refinery on the coast at Kwinana, Western Australia, licensed to use Sherritt Gordon's ammonia leach process. Plans called for its completion in 1970, with an annual production capacity of approximately 20,000 tons. In the meantime, Kambalda sulfide concentrates will continue to be treated in Sheritt Gordon's Fort Saskatchewan, Canada, refinery, and

5,000 tons per year of nickel in concentrate will be shipped to Japan. As a separate venture, Western Mining Corp. and Sherritt Gordon Mines Ltd. joined forces to explore a large lateritic deposit north of Kalgoorlie.

Also north of Kalgoorlie, shaft sinking was started at the Scotia sulfide mine of Great Boulder Gold Mines Ltd. and North Kalgurli (1912) Ltd., where reserves of 1.25 million tons of sulfide ore were reported to average 3.07 percent nickel and 0.25 percent copper. Annual nickel production of 3,500 to 4,000 tons is envisaged when production begins about August 1969.

The Nepean prospect of Metals Exploration Ltd. and Freeport Sulfur Co., south of Coolgardie, with 400,000 to 500,000 tons of nickel sulfide ore containing more than 4 percent nickel to a depth of 800 to 900 feet, was expected to develop into Australia's third producing mine by mid-1969. On the other side of Australia, the Metals Exploration-Freeport Sulfur combination was studying the possibility of developing the Greenvale lateritic deposits in a remote area of northern Queensland. Exploratory drilling on a 500-foot grid indicated 45 million tons of ore reserves, averaging 1.55 percent nickel and 0.11 percent cobalt.

In the Blackstone Range, near the point where Western Australia, South Australia, and the Northern Territory meet, Southwestern Mining Ltd., a subsidiary of The International Nickel Co. of Canada Ltd. (Inco), estimated that the Wingellina lateritic deposits contained 60 million tons of ore, averaging 1.32 percent nickel. Inco, in partnership with Broken Hill Proprietary Co., Ltd. (BHP), also investigated lateritic deposits in the Marlborough region of Queensland, as well as sulfides in the area of Kalgoorlie, Western Australia.

Table 11.—World production of nickel, by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 p
North America:					
Canada [2]	228,496	267,308	r 238,598	246,954	263,543
Cuba:					
Content of oxide e	16,200	20,200	17,500	16,650	e 30,000
Estimated content of sulfide	8,500	9,900	11,100	12,670	
United States:					
Byproduct of copper refining	949	844	1,006	1,579	2,030
Nickel recovered from domestic ore	11,236	12,666	12,281	13,036	13,124
South America:					
Brazil (content of ferronickel)	e 1,100	1,228	e 1,525	e 1,180	e 1,185
Europe:					
Finland:					
Content of nickel sulfate	162	180	204	176	195
Content of concentrates	3,532	3,295	3,254	3,812	3,556
Poland (content of ore)	1,328	1,214	e 1,400	e 1,650	e 1,650
U.S.S.R. (content of ore) e	80,000	90,000	95,000	105,000	105,000
Africa:					
Morocco (content of cobalt ore) e	370	397	430	410	NA
Rhodesia, Southern (content of ore)	173	e 770	e 770	e 770	NA
South Africa, Republic of (content of matte and refined nickel) e	2,700	3,300	6,000	6,000	6,500
Asia:					
Burma (content of speiss)	78	e 55	e 75	e [3] 30	[3] 22
Indonesia (content of ore)	r 1,850	r 3,935	r 4,335	5,642	8,663
Korea, South (content of ore)	20	1	---------	---------	NA
Oceania:					
Australia (content of concentrates)	---------	---------	---------	2,308	5,077
New Caledonia (recoverable) [4]	52,235	58,054	61,484	67,856	88,018
Total [5]	r 408,929	r 468,347	r 454,912	485,723	528,563

e Estimate. p Preliminary. r Revised. NA Not available.

[1] Nickel is also produced in Albania and East Germany, but production data are not available.

[2] Refined nickel and content of oxides and salts produced, plus recoverable nickel in matte and concentrates exported.

[3] Fiscal year October through September. Figures are for first 9 months of year noted and 3 months of previous year.

[4] Nickel-cobalt content of metallurgical plant products plus recoverable nickel-cobalt in exported ores.

[5] Total is of listed figures only.

The Anaconda (Australia)-Conzinc Rio Tinto (Australia)-New Broken Hill Consolidated partnership reported that drilling and trenching in the Widgiemooltha area of Western Australia, near Higginsville, had exposed ore in a strike length of 1,000 feet. Core obtained from three drill holes over widths of 4 to 11 feet was assayed at an average of 4 to 11 percent nickel. Plans for underground development were being considered. At Lake Lefroy, also in the Widgiemooltha area, the partnership made three other discoveries of high-grade nickel sulfides.

Canada.—Inco announced at midyear that construction was to start immediately on an $85 million refinery at Copper Cliff, Ontario. It is expected that upon completion of construction in 1971 the plant will have an annual production capacity of 125 million pounds of nickel products. The company's newly developed Inco pressure carbonyl (IPC) process for treating sulfide concentrates and metallurgical intermediates (see Technology) will be employed. The development of five new mines in the Sudbury district of Ontario, another at Shebandowan in northwestern Ontario, and three new mines in northern Manitoba, together with the new refinery and expansion at currently operating mines, will bring the company's total Canadian nickel-production capacity to 600 million pounds per year by the end of 1971.

Falconbridge Nickel Mines Ltd. was in production by September at its new Strathcona mine and mill, its largest mine and treatment complex to date. Expectations were that full production would be reached in the second quarter of 1969. The adjoining, smaller, Longvack South mine started to produce in June and reached capacity in October. Ground was broken in the Sudbury Basin for a new $35 million iron-ore concentrator that will annually treat 500,000 tons of nickeliferous pyrrhotite per year to produce 300,000 tons of iron-nickel pellets containing approximately 90 percent iron and 1.5 percent nickel. The pellets, which will be marketed in late 1969, reportedly possess technical and economic advantages for alloy and stainless steel production. A plant being built alongside by Allied Chemical Canada, Ltd., will recover almost all the sulfur (as elemental sulfur) from the roaster gases. Bulk shipment of matte from the Falconbridge smelter was successfully introduced in October by means of rail to Quebec City and thence by specially built cargo ship to the refinery at Kristiansand, Norway. The matte previously was shipped in drums.

Sherritt Gordon Mines Ltd. built a $2 million pilot plant at Fort Saskatchewan, Alberta, for hydrometallurgical treatment of 25 tons per day of laterite ore after samples from various parts of the world had been found by laboratory testing to be amenable to treatment by the company's process. In addition, a process was developed and placed in use for the treatment of an intermediate product obtained from nickel and cobalt scrap. The company's rolling mill and mint at the Fort Saskatchewan plant responded to large orders for nickel strip, coinage blanks, and finished coins.

Inco's nickel deliveries in 1968 totaled 480,840,000 pounds of nickel in all forms, compared with 463,450,000 pounds in 1967. As in previous years, this figure includes nickel purchased from various sources and sold to customers on a no-profit basis, but the quantity decreased considerably in 1968. Falconbridge nickel deliveries were 70,712,000 pounds in 1968, compared with 74,754,000 pounds in 1967. The difference between the two yearly totals is accounted for largely by 1967 shipments of nickel purchased from the U.S. Government stockpile and sold on a no-profit basis. Company-produced nickel deliveries in 1968 were slightly more than in 1967. Nickel production by Sherritt Gordon in 1968 totaled 29,598,392 pounds, of which 3,919,847 pounds was produced on a toll or custom basis. The respective 1967 figures were 25,079,525 pounds and 2,855,353 pounds.

Colombia.—In continued investigation of the Cerro Matoso lateritic nickel deposits, The Hanna Mining Co., in a joint venture with Standard Oil Co. of California through its wholly-owned subsidiary, Chevron Petroleum Company of Colombia, analyzed samples from some 500 exploratory drill holes and tested them with favorable results for amenability to production of ferronickel. Negotiations were conducted with the Colombian Government for development of the deposits, located near the town of Monte Libano in the Department of Cordoba some 200 miles south of Cartagena and not far from the boundary with the

Department of Antioquia. The basic design for a treatment process was completed and ready for testing in a pilot plant. A commercial plant capable of annually producing 25 million pounds of nickel contained in ferronickel was envisaged.

Cuba.—Both the Nicaro and Moa Bay hydrometallurgical nickel plants in Oriente Province were operated by the Cuban Government, which exported the product to East European countries and to France. Plant expansion and assistance from the U.S.S.R., Czechoslovakia, and Poland were credited for an increase in production at Moa Bay. This is the former Freeport Nickel Co. facility, now designated as the Pedro Soto Alba plant. The Nicaro plant is now called the Major René Ramos Latour Works.

Dominican Republic.—Considerable progress was reported by Falconbridge on the technical and financial aspects of its laterite project. Planned production capacity was increased to at least 60 million pounds of nickel per year contained in ferronickel, and the prospective costs were increased to $180 million. Operation of the pilot plant stopped in August, but drilling to better define the deposits continued. Drilling for foundations at the plant site was well advanced by yearend, and bids were invited in December for a general construction contract. Expectations were that the plant would be operating by the end of 1971.

Indonesia.—A contract was signed July 27, 1968, between the Indonesian Government and P.T. International Nickel Indonesia, an affiliate of Inco, for exploration and, contingent on favorable results, for development of lateritic nickel deposits in a 25,000-square-mile concession on the island of Sulawesi. Taylor-Woodrow International Limited was chosen by Inco to assist in the exploration. Indonesia's existing nickel producer, the Pomalaa mine, is also located on Sulawesi. The product is taken to Japan by the Sulawesi Nickel Development Co. (Sunideco), owned by three Japanese nickel-smelting companies.

Negotiations between the Indonesian Government and two other groups interested in nickel exploration approached the final stages. Exclusive exploration and production rights for nickel on Waigeo Island and in the Cyclops Mountains area of West Irian were being considered for Pacific Nikkel, a consortium in which United States Steel Corp. had a 43-percent interest, with the remaining ownership divided among Newmont Mining Corp., Sherritt Gordon Mines Ltd., and two Dutch firms, Hoogovens, and William H. Müller and Co. After making an exploratory survey, four Japanese nickel-smelting firms, Sumitomo Metal Mining, Nippon Mining Ltd., Nippon Yakin Kogyo Co., and Pacific (Taiheiyo) Nickel (a subsidiary of Mitsubishi and not to be confused with Pacific Nikkel), were negotiating for nickel rights on Halmahera and nearby islands.

New Caledonia.—Expansion plans of Société Le Nickel covering the next 3 years will result in an increase of annual production capacity from the current 84 million pounds to 143 million pounds. This will entail the opening of a new mine at Nepoui on the west coast, the installation of additional electric furnaces at the Doniambo smelter, include provisions for three new 35,000-kw power stations, the enlargement of port facilities, and the improvement of ore-handling equipment. The particular Le Nickel subsidiary in which Kaiser Aluminum and Chemical Corp. has an interest will participate in the financing. By 1980, it is expected that Le Nickel's annual production capacity will exceed 400 million pounds. The company has obtained exclusive rights in New Caledonia to Sherritt Gordon's hydrometallurgical process for producing a high grade product from laterites.

Plans proceeded for the formation of Cie. Francaise Industrielle et Miniere du Pacific (Cofimpac), with Inco having a 40-percent interest and various French groups, including the Bureau de Recherches Géologiques et Minieres (BRGM), the remaining 60 percent. When organization is complete, Cofimpac will proceed with development and exploitation of low-grade laterite deposits in the southern part of New Caledonia. In the meantime, exploratory drilling of these deposits continued.

Patino Mining Corporation of Canada continued its investigation of lateritic deposits, principally in the vicinity of Poum in the northern part of the island. Metallurgical testing and feasibility studies were reported to be encouraging, and exploratory drilling was accelerated.

Philippines.—Marinduque Mining and Industrial Corp. was granted the rights to develop the lateritic nickel ores on the Surigao Mineral Reservation, Nonoc Island, and the Philippine Government approved construction of a plant which will produce 50 million pounds of nickel, plus 3.54 million pounds of cobalt in mixed sulfide concentrates, per year. If preliminary studies are favorable for commercial production, the mine and refinery must be in operation by July 1973, according to the agreement. Marinduque has 31 months from July 3, 1968, in which to determine whether to proceed with the necessary expenditures. The company also reached an agreement with Sherritt Gordon Mines Ltd., which provides for the use of its hydrometallurgical process, for technical personnel, and for advice on management and operation of the plant during a 25-year period. In October, 10,000 tons of ore was shipped to the Sherritt Gordon pilot plant at Fort Saskatchewan, Canada. It was expected that pilot plant testing would be completed by the end of 1969. Nanyo Bussan Trading Co., Tokyo, Japanese sales' agent for the company, agreed to provide two-thirds of the estimated $75 million capital cost. The Philippine Government will provide approximately $7.5 million of the cost through the purchase of Marinduque convertible debentures.

South Africa, Republic of.—Early in the year, Union Corp. Ltd. signed a licensing agreement with Sherritt Gordon Mines for the use of Sherritt's hydrometallurgical process. The process will be used for nickel recovery in a special section of a new platinum refinery, presently under construction. The refinery was expected to be in operation by the end of 1969.

U.S.S.R.—Nickel was produced at three locations: Norilsk in western Siberia, where approximately 100 million pounds of nickel annually comes from sulfide ores; the Pechanga-Monchegorsk area of Kola Peninsula, with annual nickel production of approximately 50 million pounds, also from sulfides; and the southern Urals, where the country's only commercial lateritic deposits yield approximately 25 million pounds of nickel.[3]

United Kingdom.—International Nickel Ltd. announced a $10 million modernization project for its refinery at Clydach, Wales, where high-purity nickel pellets, nickel powders, and nickel and cobalt salts are produced using the nickel carbonyl process. The production capacity of hydrogen and carbon monoxide, used in the refining process, will be increased, and a second rotary kiln line installed. When the project is completed in late 1970, the long-used, multihearth plant will have been completely replaced.

TECHNOLOGY

The new refinery of Inco under construction at Copper Cliff, Ontario, will feature significant departures from the metallurgy normally employed for the recovery of nickel. Two 50-ton, top-blown, rotary converters, such as those employed in the Kaldo basic oxygen steel process, will be combined with the Inco pressure carbonyl (IPC) process to produce annually 100 million pounds of nickel pellets, 20 million pounds of nickel powder, and 5 million pounds of iron-nickel powder. Copper, cobalt, precious metals, and sulfur will also be recovered. Direct conversion of nickel sulfide to metal will be accomplished in the converters by blowing with oxygen a controlled combination (analyzing approximately 62 percent nickel, 14 percent copper, and 20 percent sulfur) of sulfide concentrates, precious-metal-bearing metallurgical intermediates, and refinery residues to produce a melt containing about 4 percent sulfur. This is the quantity of sulfur deemed best for the catalytic action needed to accelerate formation of nickel carbonyl in the following carbonylation step. The molten metal, termed "fire-refined nickel" or "oxygen nickel," will then be transferred to an induction-heated holding furnace where it will be held at 1,600° C before it is quenched to granules of appropriate size for carbonylation. After drying, the granulated metal will be transferred to the IPC plant, where it will be fed to three rotating, 150-ton capacity, carbon-steel pressure reactors. Upon pressurizing with carbon monoxide up to 70 atmospheres and heating to 180° C, a mixture of nickel and iron carbonyls will be formed in exothermic reaction as a gas containing more than 95 percent of the nickel. The carbonyl mixture will be liquefied by a brine-cooled condenser, from which the liquid will be pumped to a fractional distillation column for separation into nickel carbonyl vapor of high purity and an iron-rich carbonyl liquor having nickel-to-iron ratios of as much as 30:70. Upon heating the carbonyls in the respective decomposers, the final nickel pellets, nickel powder, and iron-nickel powder products will be obtained, together with carbon monoxide for recycling. The residue from carbonylation will be pumped to the hydrometallurgical plant for recovery of electrolytic copper, cobalt powder, sulfur, and a residue to be treated elsewhere for recovery of precious metals.

---

[3] Mining Engineering. Nickel. V. 20, No. 10, October 1968, pp. 69–116.

The process will be capable of efficiently treating a wide variety of nickeliferous materials containing iron, cobalt, and copper, with recovery of all of these elements. Effective safeguards will counter the toxic hazards accompanying the carbonyls.[3]

The more promising copper-nickel occurrences in the Duluth gabbro of Minnesota, as observed to date, lie near the base of this complex of multiple basic intrusions of Keweenawan age. The complex is exposed in an arc extending some 150 miles northeasterly from Duluth to just below the Canadian border in Cook County. Maximum width of the exposure is approximately 20 miles, and the dip is southeasterly. Thickness is unknown, but has been estimated to be several thousand feet. Gabbroic anorthosite is believed to account for approximately 60 percent of the complex, with the remainder consisting mostly of troctolite (an olivine-rich gabbro, which here has intruded into the anorthosite) and granophyre.

In one of the more promising areas under exploration by Inco, the South Kawishiwi River area near the line between Lake and St. Louis counties, copper-nickel mineralization of varying sulfide concentration occurs in troctolite as lenses or tabular bodies, as well as disseminated sulfides in the surrounding rock. The dominant ore minerals are chalcopyrite, cubanite, pyrrhotite, pentlandite, and locally bornite. Magnetite and ilmenite are common accessory minerals, and sphalerite occurs locally. Nickel values are carried almost entirely by the pentlandite. Combined copper-nickel content is less than 1 percent in a ratio of about 3-to-1. Ore-dressing tests on a bulk sample from a test pit indicated that a grind of approximately 270 mesh was required to separate the copper-iron sulfides from the nickel-iron sulfides, although a 100-mesh grind freed most of these minerals from the host rock. Nickel recoveries ranged from 50 to 85 percent; copper recoveries, from 90 to 95 percent.[4]

The ore deposit of the Marbridge No. 2 mine of Falconbridge Nickel Mines Ltd. and Marchant Mining Co. Ltd. in the Malartic mining district of Quebec, Canada, is a steep-dipping, small sulfide body with a high content of millerite (NiS). This mineral has accounted for 60 percent of the nickel produced. Pyrite, pentlandite, violarite (another nickel sulfide), and minor chalcopyrite, are other sulfides making up the ore, which consists of three types: Massive vein sulfides with silicate inclusions, disseminated sulfides in metamorphosed ultrabasics (peridotite and pyroxenite), and disseminated sulfides in metamorphosed sediments (gneiss or graywacke). The second type has provided most of the mill feed, while the third type has been the source of only a small portion of the nickel.[5]

Development of a ramp-mining system at Inco's Creighton mine in the Sudbury district of Ontario, Canada, together with processing improvements, has made it possible to mine previously unrecoverable, low-grade ores. Upon completion, scheduled for the end of the year, 16-foot-wide ramps on a 20-percent grade will connect each level from the surface to a depth of 1,875 feet. Every 30 feet, a cut will be made through slusher drifts to the boxholes, from which the ore will be drawn and carried to the ore pass by diesel-operated load-haul-dumpers.[6]

---

[3] Queneau, Paul, C. E. O'Neill, A. Illis, and J. S. Warner. Some Novel Aspects of the Pyrometallurgy and Vapometallurgy of Nickel. Paper presented at annual meeting, American Inst. of Mining, Metallurgical and Petroleum Engineers, Washington, D.C., Feb. 17, 1969.

[4] Sims, P. K. Copper and Nickel Developments in Minnesota. Min. Cong. J., v. 54, No. 3, March 1968, pp. 29–34.

[5] Buchan, R., and J. H. Blowes. Geology and Mineralogy of a Millerite Nickel Ore Deposit. Canadian Min. and Met. Bull., v. 61, No. 672, April 1968, pp. 529–534.

[6] Nickel Topics. "Ramp Mining" for Nickel. V. 21, No. 6, 1968, p. 8.

Patent applications were filed by Republic Steel Corp. for its HSO–HTCP (Hydrothermal Sulfidization Oxidation—High Temperature Cementation in Pulp) process.[7] Developed in the laboratory of the Colorado School of Mines Research Foundation, the process is designed to recover nickel from oxidized ores, including the two major types—the iron-rich laterites and the magnesium-rich soft silicates. A fine slurry of ore mixed with elemental sulfur is autoclaved at temperatures of 230° to 240° C and pressures of 380 to 480 pounds per square inch for a contact time of approximately 3 hours to form iron and nickel sulfides, together with sulfuric acid which reacts immediately with the nickel-magnesium silicates and other acid-soluble constitutents. The pulp is conveyed to oxidation autoclaves where the nickel sulfide is oxidized to soluble nickel sulfate. The iron sulfides react to form sulfuric acid and ferric sulfate which hydrolyzes to form ferric oxide and additional sulfuric acid. The acid dissolves the nickel from the remaining nickel-magnesium silicates. The addition of powdered iron to the oxidized slurry in an autoclave at 150° C gives a metallic nickel cementation product that can be recovered, along with residual metallic iron, by conventional magnetic separation equipment. Approximately 25 to 30 percent of the magnetic product is metallic nickel. Calcining at 950° C results in a mixture of metallic nickel, metallic iron, and iron oxides. It is assumed that a final ferronickel product can be obtained by melting and drawing off an oxide slag. Reacting the tailings solution with raw sulfur could yield a byproduct magnesian phosphate fertilizer, thus enhancing the economic feasibility of the process.

---

[7] Seidel, D. C., and E. F. Fitzhugh, Jr. A Hydrothermal Process for Oxidized Nickel Ores. Trans. AIME (Mining), v. 241, No. 3, September 1968, pp. 261–268.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/31

Nitrogen

By John R. Lewis[1]

The use of nitrogen compounds, primarily as ammonia in fertilizers, continued to grow in the United States and throughout the world during 1968. There was a slowdown in the rate of growth, however, and ammonia producers turned to the industrial market for new customers.

In the United States, there were early signs that annual productive capacity of anhydrous ammonia had reached a plateau at about 16.5 million tons by the end of 1968. The capacity to produce byproduct ammonia meanwhile, was about 200,000 tons per year. Nevertheless, excess capacity continued to plague the nitrogen supply structure. Weather and other agricultural vagaries did little in 1968 to provide a robust demand. Continued construction of huge new ammonia plants, featuring relatively low unit costs, foretold of possible persistence of low prices and oversupply. The closing-down or phasing-out of older and smaller high-cost plants, a more vigorous export program, and the delivery of ammonia by pipeline were watched during 1968 for their cost reducing effects upon the industry.

World production of agricultural nitrogen rose again in 1968, to 29.5 million short tons from 25.6 million in the previous year. Likewise, technical nitrogen production, worldwide, was up in 1968 to 6.9 million short tons from 6.1 million a year earlier.

---

[1] Commodity specialist, Division of Mineral Studies.

Table 1.—Salient nitrogen statistics

(Thousand short tons of contained nitrogen)

	1964	1965	1966	1967	1968 [p]
United States:					
Production as ammonia	6,447	7,465	8,904	10,210	10,108
Production as high purity nitrogen gas	2,236	2,829	3,511	4,057	4,531
Exports of nitrogen compounds	337	459	707	828	1,428
Imports for consumption of nitrogen compounds	494	496	566	691	669
Consumption [1]	6,117	[r] 6,526	[r] 7,660	[r] 9,063	9,960
World: Production [1]	21,338	24,081	27,674	31,869	36,192

[p] Preliminary. [r] Revised.
[1] Estimated, excludes nitrogen gas.

Table 2.—Nitrogen production in the United States

(Thousand short tons of contained nitrogen)

	1964	1965	1966	1967	1968 [p]
Anhydrous ammonia: Synthetic plants [1]	6,279	7,295	[r] 8,722	[r] 10,034	9,946
Ammonia compounds, coking plants:					
Ammonia liquor	18	18	[r] 11	[r] 12	14
Ammonium sulfate	144	147	[r] 162	[r] 156	142
Ammonium phosphates	11	10	[r] 9	8	6
Total	6,447	7,465	[r] 8,904	[r] 10,210	10,108
Nitrogen gas [1]	2,236	[r] 2,829	3,511	[r] 4,057	4,531

[p] Preliminary. [r] Revised.
[1] Bureau of the Census Current Industrial Reports.

Table 3.—Major nitrogen compounds produced in the United States

(Thousand short tons, gross weight)

Compounds	1967 r	1968 p
Ammonium nitrate	5,707	5,224
Ammonium sulfate	1,937	1,993
Ammonium phosphate	5,699	5,138
Nitric acid	6,265	6,135
Urea	2,091	2,428

r Revised. p Preliminary.
Sources: Bureau of the Census and Tariff Commission.

DOMESTIC PRODUCTION

In the year ending June 30, 1968, the supplies of nitrogenous materials for use in making domestic fertilizers increased 16 percent over those of the previous year. Domestic sources were turning out 18 percent more than a year earlier. During the period ending June 30, 1969, which includes the second half of calendar year 1968, the supply of nitrogenous materials was expected to increase about 7 percent over the previous year's, but with exports siphoning off some of this, the net available supply of nitrogenous materials for fertilizer use appeared about the same as the previous year.

Nitric acid production appeared slated for an estimated 6.14 million tons in 1968, only slightly below the 6.27 million tons in 1967.

In the table on recent nitrogen plant closings and startups there are a number of entries in which a company appears to have closed a certain capacity of synthetic ammonia while in the same year opening new capacity. Generally, these are cases of closing down old, multitrain units and replacing them with modern, low-cost, high quantity plants. In other instances it may be noted that a previously reported plant is repeated. This has been done where subsequent information became available altering the earlier figures.

Table 4.—Recent nitrogen plant closings and startups

(Capacities in short tons per year)

Company	Location [1]	Closings			Startups		
		Type of plant	Date closed	Capacity closed	Type of plant	Date started	Capacity started
Allied Chemical Corp	Hopewell, Va	synthetic ammonia	September 1967	400,000	Synthetic ammonia	September 1967	340,000
Do	South Point, Ohio	do	August 1968	240,000	do	August 1968	80,000
American Oil Co	Texas City, Tex				do	1968	525,000
Ammonia, Inc. (International Minerals & Chemicals Corp.)	Bonnie, Fla	synthetic ammonia	November 1968	105,000			
Arco Chemical Co. (Division of Atlantic Richfield Co.)	Point Breeze (Philadelphia), Pa.	do	1968	60,000			
Arkla Chemical Corp. (subsidiary of Arkansas-Louisiana Gas Co.)	Helena, Ark				Synthetic ammonia	1968	210,000
Borden Chemical Co	Geismar, La				Low Bi-uret urea-single reactor.	1968	183,000
Do	Houston, Tex	synthetic ammonia	July 1968	40,000			
Calumet Nitrogen Products Co.	Hammond, Ind	do	September 1968	140,000			
Caribe Nitrogen Corp	Guanica, Puerto Rico	do	May 1968	38,000			
Celanese Corporation of America.	Bay City, Tex				Nitric acid	Late 1967	48,000
Central Farmers Fertilizer Co	Donaldsonville, La				Synthetic ammonia	Target: 1969	350,000
Cherokee Nitrogen Co	Pryor, Okla				Ammonium nitrate liquid and solid.	1968	
Chevron Chemical Co	Kennewick, Wash				Nitric acid	Early 1969	62,500
Coastal Chemical Corp	Yazoo City, Miss				Synthetic ammonia	1968	365,000
	Pascagoula, Miss	synthetic ammonia	1968	180,000			
Collier Carbon & Chemical Corp. (subsidiary of Union Oil Co. of California and Japan Gas Chemical Co. Ltd.)	Kenai (Cook Inlet), Alaska.				Synthetic ammonia Prilled urea	1968–69 1968–69	550,000 55,000
Commercial Solvents Corp	Sterlington, La	synthetic ammonia	August 1968	140,000	Synthetic ammonia	1968	350,000
The Dow Chemical Co	Midland, Mich	do	July 1968	34,000			
Do	Pittsburg, Calif	do	January 1968	12,000			
Do	Plaquemine, La	do	January 1968	60,000			
E. I. duPont de Nemours & Co., Inc.	Gibbstown, N. J	do	January 1968	75,000			
El Paso Products Co	Odessa, Tex	do	January 1968	20,000			
Farmers Chemical Association	Tunis, N. C				Synthetic ammonia	1969	210,00
Farmland Industries, Inc	Plainview, Tex	synthetic ammonia	June 1968	26,000			
Gulf Oil Corp	Donaldsonville (Faustina), La.				Synthetic ammonia	Fall 1968	350,000
Do	Henderson, Ky	synthetic ammonia	September 1968	100,000	Urea	1968–69	220,000
Do	Vicksburg, Miss	do	April 1968	81,000			
Hercules, Inc	Louisiana, Mo				Nitric acid	1968	290,000
Do	do				Urea solutions	1968	64,000

See footnote at end of table.

Table 4.—Recent nitrogen plant closings and startups—Continued

(Capacities in short tons per year)

Company	Location [1]	Closings			Startups		
		Type of plant	Date closed	Capacity closed	Type of plant	Date started	Capacity started
Hill Chemicals Inc	Borger, Tex				Synthetic ammonia	1968	700,000
Hill Chemicals, Inc., with Cominco American, Inc.	Beatrice, Nebr				Ammonium nitrate	1968	200,000
Mississippi Chemical Corp	Yazoo City, Miss	synthetic ammonia	October 1967	123,000			
Miscoa Chemical Co. (Mississippi Chemical Corp., and Coastal Chemical Corp.)	do				Nitric acid	1968	110,000
Nipak, Inc	Pryor, Okla				Synthetic ammonia	1968	70,000
Nitrogen, Inc	Donaldsonville, La				do	1968–69	350,000
Phillips Petroleum Co	Beatrice, Nebr				Urea, ammonium nitrate solutions and nitrogen sulfate.	1968–69	172,000
Phillips Pacific Chemical Co. (owned 51 percent by Phillips Petroleum Co.)	Kennewick, Wash				Nitrogen solutions for urea, ammonium nitrate and nitric acid.	1968	110,000
St. Paul Ammonia Co	Pine Bend, Minn	synthetic ammonia	October 1968	90,000			
Shell Chemical Co	Pittsburg, Calif	do	December 1967	110,000			
Solar Nitrogen Corp	Lima, Ohio				Synthetic ammonia	1968–69	525,000
Southern Farm Supply Co	Plainview, Tex	synthetic ammonia	June 1968	21,000			
Tennessee Valley Authority	Muscle Shoals, Ala	do	1968	45,000			
Triad Chemical Corp. (First Mississippi Corp. and Miscoa Corp.)	Donaldsonville, La				Synthetic ammonia for urea.	1968	350,000
						1968	420,000
Wycon Chemical Co	Cheyenne, Wyo				Nitric acid	1968–69	31,000
					Ammonium nitrate	1968–69	36,500

[1] Town names in parentheses indicate other names sometimes applied to the plant's site.

At the end of January 1968, Armour and Co. announced that United States Steel Corp. had agreed to purchase the U.S. business of Armour Agricultural Chemical Co., a wholly owned subsidiary of Armour. Purchase price was not made public. The future of Armour's overseas interests, likewise, was not announced.

Undoubtedly influenced in part by the mixed outlook for nitrogen in the near term, construction of at least two big plants was delayed for the time being. Each plant had been slated to produce 350,000 short tons of anhydrous ammonia per year, and both were to have been situated in the Middle West.

CONSUMPTION AND USES

The primary use of nitrogen in the United States in 1968 continued to be for plant food. Eighty-five percent of all nitrogen was thus consumed, mostly as ammonia, (liquid or gas), ammonium nitrate, ammonium sulfate, and urea. Nitrogenous liquids, including ammonia, made up 67 percent of the total nitrogenous plant food supply in 1968. Nitrogenous solids provided the balance and urea continued to find favor among users. While urea's share of the market was not large, its steadily increased use (up 8 percent) should be noted.

The remaining 15 percent of the nitrogen used in the United States went into the production of chemicals, synthetic fibers, and explosives (industrial and military). About 62 percent of all U.S. nitric acid was used to make ammonium nitrate (down from 75 percent between 1960–65), while another 25 percent went into the making of explosives and propellants in 1968. Urethane foam materials and miscellaneous chemicals consumed the remaining nitric acid production. It is in these sectors and in fertilizers where use of nitric acid is expected to expand.

According to reports of the U.S. Department of Agriculture, 6,588,479 tons of nitrogen was consumed by the agricultural sector as fertilizers during the fiscal year ending June 30, 1968. This was an increase of 9.3 percent over the previous year's consumption, which in turn reflected a 13-percent increase over that of fiscal year 1966. The reduced rate of consumption in fiscal 1968 was believed reflective of reductions in acreage planted for food and feed grains plus adverse weather conditions in some regions. The combination of a large productive capacity and reduced demand had driven ammonia prices down to levels which made them attractive for industrial uses, of which there are around 2,500. The biggest uses were steel treating and sulphite pulping (paper).

Shipments of high purity nitrogen (in all forms) were estimated to approximate 3.5 million tons in calendar year 1968.

PRICES

Agricultural nitrogen prices remained weak during the 1967–68 fertilizer purchasing season (March 1967–February 1968), mainly because of oversupply, particularly throughout the distribution network. Concerted effort to move fertilizer materials from storage into users' hands caused further downward price pressures. Anhydrous ammonia, the most affected product, which had sold for around $113 per short ton in April 1967, was reportedly down to around $90 per short ton exactly 1 year later, and in parts of Iowa prices were as low as $70 to $80 per ton.

Fertilizer material prices (1968), as reported in trade publications and as reflected in table 5, are customarily large-lot "spot" prices to be regarded only as list prices of merchant producers and not necessarily reflective of prices at which transactions may actually have occurred. Nearly all sales of fertilizer products by producers are made under the terms of f.o.b. contracts for delivery throughout the fertilizer year. Prices usually are the result of direct negotiation between buyer and seller and for the most part are confidential. Furthermore, even at the farmer-consumer retail level, during 1968, there was ample evidence that fertilizer prices were well below those being posted. For example, 45 percent nitrogen urea, posted at $90 to $94 per short ton in bulk, was selling at Maumee, Ohio, in bags for $71 per ton, and at Nevada, Iowa, for $75 per ton. In the Maumee market area, 33½ percent ammonium nitrate, listed in table 5 at $62 to $64 per ton, sold for $55.50 per

Table 5.—Price quotations for major nitrogen compounds in 1967

(Per short ton)

Compound	January 5	December 27
Ammonium nitrate, fertilizer grade, 33.5 percent nitrogen, bulk, carlots, f.o.b. works	[1] $61–64	[1] $62–64
Ammonium sulfate, standard granular, bulk, f.o.b. works	31	23–31
Anhydrous ammonia, fertilizer, tanks, works, or freight equalized east of Rockies	[1] 60–92	[1] 60–92
Sodium nitrate, domestic, commercial, bulk, carlots, works	44	47
Sodium nitrate, imported, commercial, bulk, carlots, port warehouse	44	44
Urea:		
Industrial, 46 percent nitrogen, bags, carlots, delivered freight equalized	94	94
Agricultural, 45 percent nitrogen, bulk, 50-ton cars, works	90	[1] 90–94

[1] Differences quoted are due to quantity, quality and/or locality. They are not intended to infer prices bid or asked, nor periodic ranges.

Source: Oil, Paint and Drug Reporter.

short ton, with a $3.75 per ton discount if trucked away from the dealer's warehouse before a late January 1969 date. In central Iowa ammonium nitrate sold for $55 per ton.

During the summer, representatives of the fertilizer and ammonia-producing industries met in New York with commodity exchange officials to discuss commodity trading of ammonia futures. It was argued that such trading would firm up credit practices and spread out the heavily peaked production schedule. Others felt that difficulty in estimating return on investment could be reduced and financial risk could be spread. Still in the formative phase, no final action was taken and many adopted a "wait and see" attitude.

By September 1968, industry-wide efforts toward a more stabilized price structure had been initiated. In the face of short-term expected growth in demand, production curtailment brought about by cancellation of expansion projects, cessation of operation of relatively small and older production units, and rearrangement of distribution systems (such as inauguration of the ammonia pipeline and the unit train) all combined to begin to have remedial effects upon the somewhat chaotic price framework. However, overnight solution to the problem did not appear probable.

FOREIGN TRADE

Nitrogen exported in 1968 was about double that imported. Nitrogenous fertilizers accounted for 95.4 percent of all nitrogen exported, a slight decrease from the 96.1 percent figure for 1967. Taking up the difference in 1968 were exports of industrial chemicals (anhydrous and chemical grade aqua ammonias) which enjoyed a modest rise from 3.8 percent of the total in 1967 to 4.6 percent in 1968.

The gross weight of exported nitrogenous fertilizer materials jumped dramatically in 1968—up some 38 percent over that of the previous year. However, the value of this increase was only 13 percent, probably reflecting, among other things, a decided softening in prices and greatly increased sales to India, undertaken for the most part with financing arranged through the United States Agency for International Development (AID). The lower prices enabled AID to arrange for the sale of greater volumes for an equivalent amount of money.

In another reported instance, a rather sizable amount of ammonia was shipped to the United Kingdom, under a short-term contract, at an average value of $27 per short ton, f.o.b. This was in the face of average ammonia export values of $40 per short ton during the first half of 1968 and $80 per short ton about 2 years earlier.

Exports of urea showed important gains. Because of greater value as fertilizer, urea prices did not fluctuate in the 1968 export market. Exports were up about fourfold over those of 1967, and the value of these exports also approximately quadrupled.

Imports of nitrogenous materials, on the other hand, turned slightly downward in 1968.

Table 6.—U.S. exports and imports for consumption of major nitrogen compounds

(Thousand short tons and thousand dollars)

Compounds	1967			1968		
	Gross weight	Nitrogen content	Value	Gross weight	Nitrogen content	Value
EXPORTS						
Industrial chemicals: Anhydrous ammonia and chemical grade aqua (ammonium content)	39	32	$2,676	80	66	$3,592
Fertilizer materials:						
Ammonium nitrate	41	14	2,542	89	30	4,022
Ammonium phosphates and other nitrogenous phosphatic-type fertilizer materials	1,270	191	87,507	1,270	229	76,308
Ammonium sulfate	1,047	220	43,005	1,395	293	48,844
Anhydrous ammonia and aqua (ammonia content)	394	324	19,942	720	590	22,889
Nitrogenous chemical materials, n.e.c	27	5	2,027	26	8	1,810
Sodium nitrate	(1)	(1)	21	1	(1)	86
Urea	93	42	7,288	461	212	28,921
Total	2,911	828	165,008	4,042	1,428	186,472
IMPORTS						
Industrial chemicals: Ammonium nitrate	(1)	(1)	4	(1)	(1)	2
Fertilizer materials:						
Ammonium nitrate	177	58	9,121	227	76	11,344
Ammonium nitrate-limestone mixtures	3	1	101	7	1	210
Ammonium phosphates	212	32	17,720	247	47	17,264
Ammonium sulfate	168	35	5,908	131	28	4,352
Calcium cyanamide or lime nitrogen	18	4	1,036	17	4	1,709
Calcium nitrate	32	5	742	42	7	990
Nitrogen solutions	73	25	3,420	72	22	3,232
Anhydrous ammonia	443	364	19,126	401	329	18,500
Potassium nitrate or saltpeter, crude	[r] 19	2	697	16	2	656
Potassium nitrate, sodium nitrate mixtures	45	7	1,702	28	4	1,009
Sodium nitrate	218	35	6,790	205	33	6,715
Urea	260	118	16,438	248	114	15,471
Other	24	5	1,275	11	2	767
Total	[r] 1,692	691	84,080	1,652	669	82,221

[r] Revised.
[1] Less than ½ unit.

WORLD REVIEW

Argentina.—The $25 million major petrochemical fertilizer complex, Petrosur SAIC, located at Campana, 50 miles northwest of Buenos Aires in Buenos Aires Province, was opened in the late spring of 1968. The plant has a revised annual design capacity of 150,000 tons of synthetic nitrogenous fertilizer materials, utilizing natural gas as the raw material. Argentine and European capital, the Inter-American Development Bank, and Ebasco Industries are reported to have participated in the project. The Petrosur complex, consisting of five integrated plants, will produce intermediate products and finished nitrogenous and mixed fertilizers. Revised daily outputs are expected to be synthetic ammonia, 200 tons; urea, 162 tons; sulfuric acid (98 percent), 98 tons; and ammonium sulfate, 147 tons.

Table 7.—World production and consumption of fertilizer nitrogen compounds, years ended June 30, by principal countries r

(Thousand short tons of contained nitrogen)

Country	Production •			Consumption •		
	1965–66	1966–67	1967–68	1965–66	1966–67	1967–68
Argentina	2	1	2	33	31	35
Australia	37	49	61	77	119	132
Austria	231	257	268	100	99	111
Belgium	376	350	397	168	174	181
Brazil	16	7	8	83	75	129
Bulgaria	278	327	390	255	298	358
Canada	418	526	618	240	305	358
Ceylon	-------	-------	-------	41	43	50
Chile	202	165	187	41	40	39
China, mainland	750	860	937	1,465	1,956	1,819
Colombia	43	39	44	44	45	50
Cuba	-------	6	11	99	159	187
Czechoslovakia	243	277	288	278	289	298
Denmark	28	28	44	211	287	256
Finland	76	88	116	106	111	125
France	1,146	1,308	1,470	970	1,079	1,180
Germany:						
East	384	379	370	452	477	434
West	1,564	1,655	1,720	968	980	1,047
Greece	84	129	132	150	168	176
Hungary	163	184	207	248	284	287
India	283	340	396	625	986	1,580
Indonesia	52	46	48	109	121	154
Ireland	38	39	41	41	54	60
Israel	25	25	26	24	28	29
Italy	986	1,036	1,200	504	585	584
Japan	1,800	1,972	2,183	849	919	959
Korea:						
North	116	123	143	116	124	143
South	83	96	270	281	296	322
Malawi, Southern Rhodesia, Zambia	-------	-------	-------	52	51	61
Mexico	171	176	200	305	341	380
Netherlands	619	754	936	343	372	378
Norway	365	359	410	69	68	77
Pakistan	93	102	116	179	283	287
Peru	21	19	23	51	40	45
Philippines	11	23	40	43	72	79
Poland	435	509	655	488	518	620
Portugal	124	127	132	101	85	112
Rumania	188	291	410	174	228	351
South Africa, Republic of	76	85	116	109	108	144
Spain	304	366	480	452	466	518
Sweden	101	132	152	178	181	187
Switzerland	34	31	32	28	34	35
Taiwan	177	192	206	209	204	208
Trinidad	57	332	405	5	5	5
Turkey	36	36	36	94	121	146
U.S.S.R	2,725	3,131	3,582	2,630	2,928	3,405
United Arab Republic	169	178	187	311	298	325
United Kingdom	724	787	942	694	753	828
United States	5,689	6,237	6,872	5,313	6,048	6,589
Yugoslavia	103	116	124	183	218	249
Other:						
North America [1]	46	53	62	118	127	138
South America	19	15	25	45	47	57
Europe	10	8	14	25	26	31
Asia	18	67	119	230	294	360
Africa	-------	4	11	141	179	218
Oceania	-------	-------	-------	12	14	14
World total	21,729	24,442	27,813	21,155	24,036	26,770
Estimated losses (in transit, bagging, etc.)	-------	-------	-------	317	361	402

• Estimated. r Revised.

[1] Includes Central America.

Source: Nitrogen (London), No. 57 January-February 1969, pp 16–17.

Australia.—In 1968, construction began on Austral—Pacific Ltd.'s $45 million fertilizer plant at the company's complex at Gibson Island near Brisbane, Queensland. Raw material will be natural gas from the Roma gas field. The single-train plant was reported to be capable of producing 250,000 tons of urea per year and about the same amount of anhydrous ammonia. Completion target was early 1969. Austral-Pacific is largely owned by Skelly Oil Co., Swift & Co., and The Dow Chemical Co.

During 1968, depressed prices in the world nitrogen markets created some uncertainty in Australia, especially with respect to construction or expansion of indigeneous nitrogen producing facilities. In general, it was possible to buy imported nitrogeneous materials cheaper than they could be made in Australia, despite new capacity coming on stream during the year. Esso Chemicals Australia suspended further marketing operations in New South Wales and dropped building plans of a year earlier involving four manufacturing sites. Amalgamated Chemicals, Ltd., controlled by Continental Oil Co. (U.S.), also deferred plans to build and announced intent to sell imported fertilizer materials, including ammonia.

Belgium.—A new 100,000-ton-per-year urea and 300,000-ton-per-year ammonia plant began operation late in the year at Societé Carbochimique's site at Tertre. It was designed to use natural gas as feedstock to the ammonia plant (built by Kellogg) and the new Stamicarbon process for making urea.

Bulgaria.—The third Bulgarian nitrogen complex, near Vratza, was commissioned toward the end of 1968. Its annual production capacity of ammonia is scheduled to reach 400,000 tons per year. The complex was made possible as a result of the discovery of natural gas at Chiren, near Vratza.

Technical expertise during construction was provided by contracting firms from Belgium, France, and the United Kingdom.

Another chemical combine, with a production capacity of 200,000 tons per year of ammonia and large amounts of phosphate will be built during the next few years near Varna. A contract for the construction and equipment for this combine has already been signed with the same companies which constructed the Vratza plant.

Chile.—Sociedad Quimica y Minera de Chile S.A. emerged, during 1968, as the new company formed by the Chilean Government with several nitrate companies to develop further Chile's large natural nitrate deposits. The Anglo-Lautaro Nitrate Corporation, Corporación de Fomento de la Producción (CORFO) and the absorbed COVENSA (Corporacion de Ventas de Salitre y Yodo de Chile) all contributed facilities to the revitalized venture, which reportedly has an initial capitalization of $40 million. Although at the outset the thrust of the corporation's efforts were to be with nitrates, iodine, and their derivatives, future activities were also aimed at development of magnesium, titanium, and sulfur resources.

Table 8.—Chile: Exports of nitrate in 1968, by countries

(Short tons)

Country of destination	Quantity
Argentina	8,848
Australia	3,564
Brazil	34,333
Canada	5,264
Colombia	961
Denmark	5,116
Ecuador	435
El Salvador	256
France	16,881
Japan	11,534
Lebanon	3,069
Mexico	21,007
Peru	2,638
Portugal	3,581
Spain	20,247
United Kingdom	3,222
United States	200,783
Uruguay	544
Other countries	91,579
Total	433,862

China, Mainland.—The China National Chemical and Export Corporation, mainland China's fertilizer trading organization, increased its world-leading purchases of nitrogen fertilizers in 1968 by some 14 percent over those of the previous year. Suppliers were Nitrex A.G., a Swiss-based central sales organization acting for major producers in Germany, Italy, and France; several groups in Japan; and Imperial Chemical Industries, Ltd., (ICI) a British chemical group. Ammonium sulfate and urea were the main compounds purchased.

Germany, West.—Traditionally strong in the export of nitrogeneous materials, West Germany dropped to third place among the world's exporters behind Japan and the United States during the latter half of 1968. Competition in export markets was expected from all other European nations, especially from Italy and the Netherlands where raw materials were increasing and prices were low. Domestically, producers were faced by discounts from foreign companies seeking markets in West Germany, and consumption did not rise as much as in nearby Belgium and the Netherlands. By the end of 1968, prices had been lowered several times to meet competition, despite slight price rises in nearby countries. Exports through Nitrex were expected to ease some of the oversupply problems.

Badische Anilin- & Soda-Fabrik (BASF) was reported to be replacing several older synthesis units with a 400,000-ton-per-year single-train ammonia plant at its Ludwigshafen facility. Britain's Humphrey's & Glasgow handled design and engineering of the synthesis gas plant. Completion is scheduled for early 1970.

Dutch natural gas for feedstock and for boiler fuel for power will be used at the ammonia plant-fertilizer unit of Enterprise Miniere et Chimique and Wintershall of West Germany, to be built at Ottmarsheim.

Greece.—Late in 1968 the Greek Government announced control measures for the fertilizer industry and its markets in the country. Fertilizer stocks, imports, and the establishment of new production facilities were involved.

The Agricultural Bank of Greece was to purchase all existing stocks of chemical fertilizers held by domestic manufacturers and would take all manufacturers' output in the future.

Import permits would be issued henceforth only for those fertilizers which are manufactured not in Greece, and no new plants would be approved if designed to produce fertilizers already made in Greece.

Companies in Greece at yearend produced ammonium phosphate sulfate, single superphosphate, triple superphosphate, phosphoric acid, ammonia, ammonium sulfate, ammonium nitrate, lime ammonium nitrate, and various mixtures. There was an indicated 155,000-ton-per-year ammonia production capability in Greece at the close of 1968.

Guatemala.—Components for Guatemala's first fertilizer complex, at Escuintla, were ordered late in 1968. Stamicarbon was to furnish a urea plant rated at 60,000 short tons per year. Lummus Co. was the contractor and total cost was put at around $15 million. A 300,000-ton-per-year ammonia plant, to operate in connection with the urea plant will use Mexican petroleum for feedstock. Although construction was initiated by the Government, it was expected that the plant ultimately will be sold to private enterprise.

India.—India continued to be short of all fertilizers but the biggest need was nitrogen. Present (1968) nitrogen capacity was listed as 805,000 short tons per year but production was expected to be around 550,000 short tons. India's problems in attracting foreign investment appeared to continue despite major inducements. Furthermore, with ample world fertilizer supplies, it appeared that foreign companies were disposed more to send fertilizer to India than to build plants there. Nitrogen consumption in India was more than 1 million tons in 1968.

Six projects, which will add around 725,000 short tons per year, were in various stages of construction in 1968, and others aimed at a grand total nitrogen capacity of around 2 million short tons per year by 1970–71 were already committed.

The Power-Gas firm announced that it, with associates, plans to design and construct a complete $45 million fertilizer complex at Goa on India's west coast. The project will include plants to produce 600 tons of ammonia and 1,030 tons of urea daily, and will include docks, water supply, waste treatment facilities, and a permanent residential area.

Indonesia.—The national oil and gas production company of Indonesia, Pertamina, with Universal Chemicals of Nassau, Bahamas, was preparing to proceed with the building and operation of a $65 million, 350,000-short-ton-per-year anhydrous ammonia-to-urea and nitrogen solution fertilizer plant, probably to be located in West Java. Indonesian nationals would be trained to operate the facility, which would be their nation's largest manufacturing facility.

Meanwhile, Japan agreed, in mid-1968, to extend $80 million in economic aid to Indonesia and 4 days after the agreement was signed the Japanese fertilizer industries began preparing 108,000 short tons of urea for shipment to Indonesian ports.

Japan.—Conversion by Japan's nitrogen industry to large, economical production units, which began a year or so earlier, continued with considerable velocity in 1968.

Mitsubishi Chemical Industries Ltd. went ahead with replacement of their 465-ton-per-day plant at Kurosaki, Fukuoka Pref. and engaged Chemical Construction Corp., a subsidiary of Ebasco Industries Inc., to supply the process know-how and engineering for an 1,100-ton-per-day ammonia plant. Featuring a single-train design, and using centrifugal compression, the plant will use surplus coke oven gas from other plants in the Kurosaki complex as fuel for the naphtha reforming facilities. Most of the output from the larger plant will be used for production of caprolactum, acrylonitrile, and other ammonia derivatives, with only about a third of the output going into fertilizers.

What may be the world's largest ammonia unit was in the planning stages by Nihon Ammonia Company, formed in November 1968 by Sumitomo Chemical Co., Seitetsu Kagaku Kogyo Co., Showa Denko K.K., and Nissan Chemical Industries Ltd. Although the site had not been announced, one place apparently under study was the Chiba industrial belt, near Tokyo. Determination to have the 1,650-short-ton-per-day ammonia plant on stream during 1970 was made public, however. Also, a large capacity urea plant was planned for concurrent construction.

In addition, two Japanese companies—Tohoku Hiryo and Nippon Suiso Kogyo—were scaling up plans for a joint ammonia fertilizer plant scheduled to go into production in December 1969. Originally laid out for 750 tons per day, the $33.3 to $36.1-million facility at Onahama was projected, during 1968, to a 1,000-ton-per-day output level.

Kuwait.—Kuwait Petrochemical Industries Company was proceeding with another of the big ammonia/urea projects under way in the Persian Gulf area. Two units, each capable of 231,000 tons of urea per year, were to be built and supplied by two separate ammonia units under construction nearby, each of which will have capability for 265,000 tons per year. Provisions have been made for a third ammonia unit when it becomes necessary. Natural gas will be the raw material source. Completion of the entire project was scheduled for the autumn of 1969. Overall, the cost was expected to run about $60 million. When ready, Kuwait will have enlarged its petrochemical production fivefold over its first beginnings in this field.

Mexico.—During the summer of 1968, plans were announced by Guanos y Fertilizantes de Mexico S.A. to build a 750-ton-per-day urea plant valued at $7.5 million at Minatitlan, Vera Cruz. The company had engaged SNAM Progetti who planned to utilize one of its own original processes in the plant. Local supplies and civil engineering were to be supplied from Mexican sources and the turnkey job was slated for completion during the summer of 1971.

A 150-mile anhydrous ammonia pipeline[2] crossing the Mexican isthmus from Minatitlan near the Gulf of Mexico to Salina Cruz on the Pacific Ocean was completed in 1968.

Netherlands.—During 1968 Esso Chemie N.V. started up its Europoort fertilizer complex, said to be among the world's largest such installations. During the planning and early development stages, the capacities of the various units were increased several different times. As completed, the complex comprises an ammonia plant (500,000 tons per year), the largest single-train plant to date in Europe; a nitric acid plant (250,000 tons per year); a calcium ammonium nitrate plant by Fredriech Uhde (400,000 tons per year); and a urea plant (188,000 tons per year), which converts all ammonia and carbon dioxide feed into urea. The complex uses Dutch natural gas as feedstock for production of urea and calcium ammonium nitrate. Cost of the entire project was around $70 million.

There were several other important additions to the burgeoning Dutch petrochemical fertilizer production capability during the year. Among these were announcements during the summer by both Nederlandse Stikstof Maatschappij N.V. and by the government's Dutch State Mines (DSM) that each planned almost to double its urea output via plant enlargements. Both companies were preparing for expanded activity in the mixed fertilizer markets as well. Much of this production was and will be exported, mostly to West European buyers.

---

[2] Fertilizer and Feeding Stuffs Journal. V. 65, No. 14, July 17, 1968, p. 459.

Poland.—Said to be the largest fertilizer complex in the world, Pulawy I and Pulawy II, went on stream in June 1968 at a point on the Vistula River some 100 miles south of Warsaw. A French firm, Kaltenbach and Co., was the construction contractor. The complex consists of three plants, each with a 400,000-ton-per-year ammonia capacity. Units downstream from the ammonia plant produce nitric acid, urea, and ammonium nitrate. Newly developed output alone is expected to be around 530,000 tons of pure product annually. Feedstock is natural gas pipelined from the U.S.S.R., but Polish natural gas may later be used. The plant is highly automated; it is said that six to 10 persons can operate it.[3]

Qatar.—Power-Gas Corporation of Britain has targeted a mid-1972 date for completion of a $44.4 million nitrogenous fertilizer plant at Umm Said (Musay'id) on Qatar's eastern coast near the Persian Gulf. The plant will have capacity for 365,000 tons of urea and 105,000 tons of ammonia per year. Feedstocks will be natural gas produced in the country.

Saudi Arabia.—At Dammam, the Saudi Arabian Fertilizer Co., owned 51 percent by the Saudi government and 49 percent by private Saudi investors, was proceeding during the year with construction of a giant urea plant. Using gas formerly wasted, the plant will produce 600 tons per day of ammonia which will be converted into 1,100 tons of urea per day, most of which will be exported to world markets. Estimates of total cost, originally set at around $30 million, rose to around $40 million during the year.

Spain.—An ammonium nitrate plant (prill process) at Seville went into operation during 1968, under ownership of Abonos Seville S.A., a member of the Union Española de Explosives group.

Spain and Algeria were negotiating, during the year, to trade Algerian ammonia for Spanish fertilizer. Algeria's oil agency, Sonatrach, was building a 1,000-ton-per-day ammonia plant at Arzew near Oran, on the Mediterranean which reportedly can ship to Spanish fertilizer makers at less than $40 per ton, c.i.f., beginning in 1970. Spanish fertilizer plants in Huelva, Malaga, Algeciras, Cartagena, and Tarragona then will return finished fertilizers to Algeria at so-called "reasonable" prices.

United Kingdom.—In 1968, availability of North Sea natural gas created possibilities for considerable nitrogen fertilizer raw material cost savings (estimated at $7 per ton in ammonia production) and a number of firms were negotiating for the gas which appeared about to usurp naphtha as feedstock in many plants by 1970–71. Both Imperial Chemical Industries and Shellstar Ltd. were actively engaged in final negotiating for big gas reserves.

A high-purity nitrogen plant built by Air Products, Ltd., was ready for operation at yearend at an undisclosed chemical complex in Northern Ireland, presumably Du Pont. The 148,000-ton-per-year facility will produce liquid nitrogen to storage for peak or special requirements at the complex.

Another nitrogen plant by Air Products, Ltd., was to be built for Shell Chemicals U.K. at Stanlow, Cheshire. It will be totally automated and will operate as a satellite to an existing facility at Carrington. Cost was estimated to be about $600,000.

Venezuela.—The Lake Maracaibo area was the scene, in 1968, of the beginnings of a $90 million project featuring, as part of a petrochemical installation, another ammonia plant of 1,500 tons per day capacity. To be built at Bajo Grande, the facility is a cooperative project by the state-owned Venezuelan Petrochemical Institute and four U.S. oil companies, Venezuelan Atlantic Refining, Venezuelan Sun Oil, Texaco Maracaibo, and Texaco Seaboard. Using some 45 million cubic feet of gas daily, the plant is scheduled to go onstream in mid-1970. Output will mainly be sent to fertilizer plants in Latin America. The plant is part of a large interdependent petrochemical and fertilizer complex on specially setaside land called El Tablazo in Zulia State.

---

[3] Pulawy Fertilizer Complex Starts Production. European Chemical News (London). V. 14, No. 336, July 12, 1968, p. 7.

TECHNOLOGY

Continued reduction in costs was the main thrust of research, development, and distribution techniques in 1968.

A major step, considered by some to be still subject to scrutiny, was the ammonia pipeline, of which two were well underway in the United States during 1968, while a third was under consideration by a group of chemical and petroleum companies. Generally, these lines are expected to operate in conjunction with large, low-cost ammonia production facilities.

A common carrier ammonia pipeline, operated by Mid-America Pipeline Co. (MAPCO) of Tulsa, Okla., starts at Borger, Tex., in the Panhandle gasfields area and extends northeasterly across central Kansas, eastern Nebraska, and into a western Iowa terminus at Garner. The line is 850 miles long, cost $18 million, and boasts five distribution terminals and one 80,000-ton storage area. By this means, ammonia plants may locate close to lowest cost feedstocks and can send their output hundreds of miles distant. Competition from barges, trucks or unit-trains was still an unknown factor in 1968, however.

Ammonia for the 6- and 8-inch MAPCO line became available from the newly opened (October 1968) 350,000-short-ton-per-year single-train plant of the Hill Chemicals Inc., at Borger where additional productive facilities were also under development. Meanwhile, a second independently owned and operated common carrier anhydrous ammonia pipeline system was under construction at the end of 1968. It was scheduled to begin operation during the summer of 1969. Built to transport ammonia from the major producing areas of the Texas and Louisiana gulf coast to consuming centers in Iowa, Illinois, Nebraska, Indiana, and Missouri, the new line, varying in diameter from 6 to 10 inches, will be known as the Gulf Central, and generally will run parallel to the Mississippi River, 50 to 100 miles to the west. More than 1,800 miles of line will be involved although the main northbound 10-inch trunk, from Alexandria, La. to Hermann, Mo., will be 548 miles long.

Owners of the Gulf Central line were listed as the Gulf National State Bank of Houston, Tex.; Cabot Corporation of Boston, Mass.; Loeb, Rhoades and Co., New York; and a subsidiary of the Atchison, Topeka and Santa Fe Railway.

The Coast-Midwest Pipeline Corp., formed in 1967 by several large petroleum and chemical companies, was studying the feasibility of another common carrier line from Lake Charles, La., to Midwestern areas.

Experiments also were under way in 1968 to determine the feasibility of shipping fertilizer solutions through regular petroleum products pipelines under the batching system normally used. Allied Chemical and Williams Brothers shipped at least one 25,000-barrel (42-gallon) batch over a 131-mile segment of line between Nebraska City and Doniphan, Neb.[4]

Another cost-saving step was the growing use of ever larger liquid ammonia storage tanks and the enlargement of terminals. Hawkeye Chemical Company began construction, at Clinton, Iowa, on the Mississippi River, of a $1-million storage tank which would hold 30,000 short tons of ammonia and would at least double the availability of ammonia at that point, in the heart of the Iowa-Illinois corn belt. Hawkeye also operates a 140,000-short-ton-per-year synthetic ammonia plant at Clinton.

At Sioux City, Iowa, the Borden Chemical Co. completed another 30,000-short-ton ammonia facility on the Port Neal Industrial Area. It was stated that this terminal would service Borden's customers in Iowa, Minnesota, South Dakota, and Nebraska.

Still a third 30,000-short-ton tank terminal, which would keep ammonia liquid at −28° F, was under construction for the W. R. Grace Agricultural Chemicals Group at Fort Dodge, Iowa.

In another direction, a 72,000-short-ton-per-year ammonium sulfate plant using natural gypsum was on the drawing board in 1968 and intended for construction somewhere in California. The project was being prepared by the Power-Gas Corporation of America, a subsidiary of Power-Gas, Ltd., of Great Britain.

---

[4] "Nitrogen" Magazine. No. 51, January–February, 1969, p. 39.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/196

Peat

By Joseph J. Gallagher[1]

Domestic peat production rose 0.3 percent in 1968, continuing the upward trend begun in 1965. Michigan, the largest producer, accounted for 39 percent of the output. Commercial sales totaling $7.2 million and an average price of $11.68 per short ton were new highs. Imports were up 2.4 percent. The U.S.S.R. produced approximately 99 percent of the estimated world output of 211 million short tons.

Table 1.—Salient peat statistics

	1965	1966	1967	1968
United States:				
Number of operations	146	144	131	135
Production short tons	604,082	611,085	617,172	618,995
Commercial sales do	630,746	605,858	619,687	619,161
Value of sales thousands	$6,080	$6,501	$6,768	$7,230
Average per ton	$10.07	$10.73	$10.92	$11.68
Imports short tons	275,462	293,843	280,842	287,600
Available for consumption[1] do	879,208	899,701	900,529	906,761
World production thousand short tons	201,626	224,041	218,576	211,222

[1] Commercial sales plus imports.

PRODUCTION

The 0.3-percent increase in the production of peat resulted from continued strong demand for its use in soil improvement. The output was 75 percent larger than the average quantity produced during the base years 1957 to 1959. Increases in production in Florida, Illinois, New Jersey, Michigan, Colorado, Maryland, and Wisconsin more than offset decreases in 17 other States.

Michigan continued to be the principal producer of peat, with 25 operations and 39 percent of domestic output. Michigan's production increased 3.7 percent above that of 1967, with one less plant in operation. The other major producing States, in order of magnitude, were Illinois, New Jersey, Florida, Washington, Pennsylvania, Indiana, Colorado, New York, Minnesota, and Ohio. All told, 25 States produced peat in 1968.

Individual operations increased from 131 to 135, but the average production per plant declined from 4,711 tons in 1967 to 4,585 tons. Nearly 80 percent of the plants produced less than 5,000 tons in 1968, accounting for only one-fourth of the total output. Plants producing between 5,000 and 25,000 tons per year accounted for 44 percent of the total, and the four largest plants, producing in excess of 25,000 tons, were responsible for the remaining 31 percent.

Fifty-five percent of the total peat production was reed-sedge peat, 28 percent was moss peat, and the remaining 17 percent was humus. This represents a production increase of 8 percentage points for reed-sedge and moss peats, but a decrease of 8 points for humus. Sixty-two percent of the peat output was produced by cultivation methods, and 82 percent was processed by shredding and/or artificial drying before it was marketed.

Although methods of production varied, almost all the peat was extracted with machinery. Most of the harvesting equipment consisted of conventional earth-mov-

---

[1] Supervisory industry economist, Division of Mineral Studies.

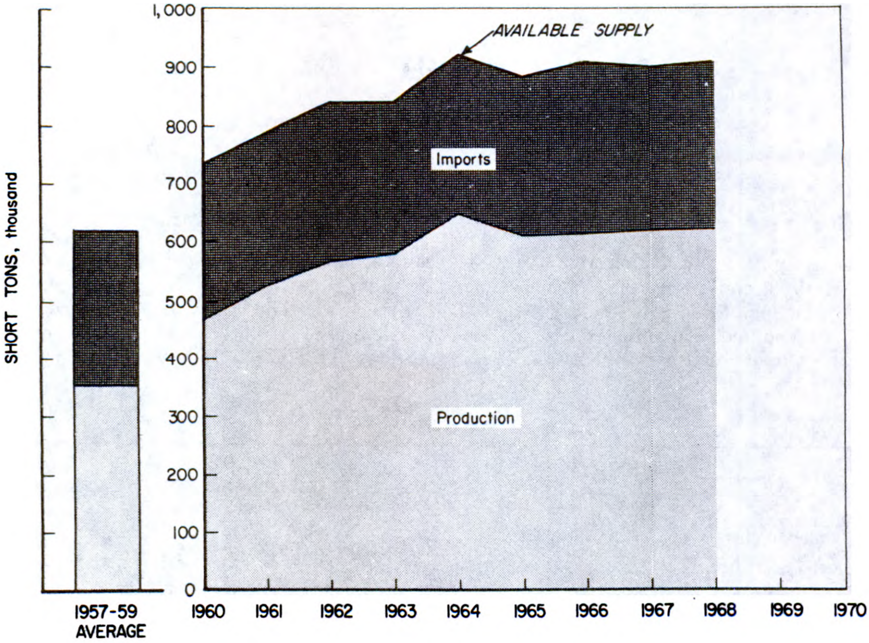

Figure 1.—Production, imports, and available supply of peat in the United States.

ing and excavating machines, including power shovels, clamshells, draglines, bulldozers, and front-end loaders. Some specialized machines, such as harvesters, cultivators, milling machines, ridgers, and scrapers, were used. Processing machinery included a variety of shredders, pulverizers, hammermills, grinders, screens, hydraulic presses, and artificial dryers.

Table 2.—Peat produced in the United States in 1968, by kinds

(Short tons)

Kind	Unprepared	Processed			Total
		Shredded	Kiln-dried only	Shredded and kiln-dried	
Moss	45,787	123,088	-----------	1,760	170,635
Reed-sedge	34,367	303,037	3,200	-----------	340,604
Humus	28,720	75,193	500	3,343	107,756
Total	108,874	501,318	3,700	5,103	618,995

Table 3.—Production and commercial sales of peat in the United States in 1968, by States

State	Active plants	Production (short tons)	Commercial sales		
			Short tons	Value	
				Total (thousands)	Average per ton
California	3	W	W	W	W
Colorado	17	28,457	28,457	$250	$8.79
Florida	11	41,213	41,213	277	6.72
Georgia	2	W	W	W	W
Idaho	1	W	W	W	W
Illinois	7	61,520	61,520	867	14.10
Indiana	6	29,698	38,763	557	14.37
Iowa	2	W	W	W	W
Maine	2	W	W	W	W
Maryland	2	6,161	5,554	94	16.94
Massachusetts	[1] 1	W	W	W	W
Michigan	[1] 25	243,125	237,513	2,919	12.29
Minnesota	7	7,263	6,400	96	15.01
Montana	1	W	W	W	W
New Jersey	6	55,786	55,786	621	11.13
New Mexico	1	446	446	4	10.00
New York	[1] 4	14,330	14,888	153	10.27
North Dakota	1	W	W	W	W
Ohio	[1] 11	6,483	6,506	94	14.42
Oregon	1	360	360	11	29.48
Pennsylvania	9	38,403	35,806	385	10.74
South Carolina	1	W	W	W	W
Vermont	1	W	W	W	W
Washington	11	40,440	40,440	159	3.93
Wisconsin	2	2,642	1,902	153	80.40
Total	135	618,995	619,161	7,230	11.68

W Withheld to avoid disclosing individual company confidential data; included in total.
[1] Excludes 1 plant which had sales, but did not produce.

Table 4.—Relative size of peat operations in the United States

Size	1967				1968			
	Active plants		Production		Active plants		Production	
	Number	Percent of total	Short tons	Percent of total	Number	Percent of total	Short tons	Percent of total
Under 500 tons	27	20.6	5,163	0.8	30	22.2	6,583	1.0
500–999 tons	18	13.7	12,033	1.9	17	12.6	11,035	1.8
1,000–4,999 tons	53	40.5	118,252	19.2	59	43.7	135,980	22.0
5,000–14,999 tons	26	19.8	229,510	37.2	20	14.8	176,980	28.6
15,000–24,999 tons	3	2.3	64,143	10.4	5	3.7	93,717	15.1
Over 25,000 tons	4	3.1	188,071	30.5	4	3.0	194,750	31.5
Total	131	100.0	617,172	100.0	135	100.0	618,995	100.0

CONSUMPTION AND USES

The 526-ton decrease in producers' sales of domestically produced peat was more than offset by an increase of 6,758 tons in imports in 1968, which placed 6,232 tons more than the 1967 amount on the market.

Eighty-nine percent of the peat marketed by domestic producers was sold for soil improvement. The principal buyers were nurseries and greenhouses; landscape gardeners and contractors; and garden, hardware, variety and chain stores. The remaining 11 percent was sold primarily to pack flowers and shrubs and for potting soils and mixed fertilizers. The amount sold for packing flowers and shrubs increased in 1968 to nearly four times the 1967 sales' level. No peat was reported sold for fuel or energy use.

About one-half of the peat was sold in bulk, and the remainder was marketed in packages. Bulk sales were down from the

1967 level by nearly 6,000 tons, but packaged sales were up by more than 5,000 tons. Commercial sales were 81 percent greater than the average quantity sold from 1957–59. Of the total packaged sales, more than two-thirds was reed-sedge peat, and Michigan produced more than one-half of this. Most of the remaining packaged peat was produced in Indiana, Illinois, New Jersey, and New York. Detailed State data on bulk and packaged sales are not shown in order to avoid disclosure of individual company information.

Table 5.—Commercial sales of peat in the United States in 1968, by kinds and uses

(Thousand short tons and thousand dollars)

Use	Moss		Reed-sedge		Humus	
	Quantity	Value	Quantity	Value	Quantity	Value
Bulk:						
Soil improvement	54	$482	131	$963	60	$480
Other uses	15	94	13	118	25	198
Total [1]	69	576	144	1,082	85	678
Packaged:						
Soil improvement	80	1,369	206	2,606	21	297
Other uses	(2)	4	9	403	5	217
Total [1]	80	1,372	215	3,009	26	513
Total:						
Soil improvement	134	1,850	337	3,570	81	777
Other uses	15	98	22	522	30	415
Grand total [1]	149	1,948	359	4,091	111	1,191

[1] Data may not add to totals shown because of independent rounding.
[2] Less than ½ unit.

Table 6.—Commercial sales of peat in the United States in 1968, by uses

(Thousand short tons and thousand dollars)

Use	In bulk		In packages		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
Soil improvement	245	$1,925	307	$4,271	552	$6,196
Potting soils	7	51	10	413	17	464
Packing flowers, shrubs, etc.[2]	37	284	2	25	38	309
Seed inoculant	(3)	4	2	185	3	190
Mushroom beds	4	39	-----	--------	4	39
In mixed fertilizers	6	32	-----	--------	6	32
Total [1]	298	2,336	321	4,895	619	7,230

[1] Data may not add to totals shown because of independent rounding.
[2] Includes small amount sold for earthworm culture.
[3] Less than ½ unit.

PRICES AND SPECIFICATIONS

The average per ton value of domestically produced peat sold in 1968 rose $0.76 to a new high of $11.68 per ton, f.o.b. plant. The total value of commercial sales reached $7.23 million, also a record high.

Peat prices at individual plants varied greatly, depending upon the kind of peat, the amount of processing, and the packaging. The average value of bulk peat was $7.84 per ton; however, prices ranged from an average of $13.33 per ton for peat used in seed inoculant to $7.43 per ton for peat used in potting soils. The same situation applied to packaged peat, which averaged $15.25 per ton, but which ranged in price from $13.90 per ton for peat used in general soil improvement to $83.07 per ton for peat sold as seed inoculant.

Imported peat was valued at $12.8 million, an increase of 4.3 percent over the 1967 total. This value, established at the port of embarkation, was approximately equal to prices paid by importers, less transportation and other miscellaneous charges. In some cases, ocean freight and other nondutiable charges, such as insurance, may have been included inadvertently. The average value of imported peat was $44.56 per short ton, $0.85 higher than the average in 1967. Most of the increase was attributable to the higher values of peat imported from Canada and West Germany.

The short-ton price of imported peat was about 3 times that of packaged, domestically produced peat. The values are not comparable, however, because they were determined at different marketing levels. In addition, imported peat has physical properties different from most of the peat produced in the United States, and it is usually sold by volume rather than by weight. Each 100 pounds of a typical air-dried imported peat will measure about 12 bushels, whereas the same quantity of a typical domestic peat will measure 3 or 4 bushels. Only a few U.S. operations produce and sell peat with properties similar to those of the imported kind.

Peat is broadly classified as moss peat, reed-sedge peat, and humus in the United States. Moss peat was formed largely from sphagnum, hypnum, or other mosses. Reed-sedge peat originated principally from reeds, sedges, and similar swamp plants. In both of these types of peat, the plant remains can be identified. Humus includes all peat that is too decomposed for identification of its botanical origins. The Federal Trade Commission regulates the labeling and marketing of all peat sold in the United States. Peat sold to the Federal Government is subject to specifications developed by the Federal Supply Service, General Services Administration. The latest specification, Q-P-166e, effective May 10, 1961, is in general conformity with the aforementioned classification system; however, the moss type is subdivided into two groups called "sphagnum-moss peat" and "other moss peats."

FOREIGN TRADE

Imports in 1968 were 2.4 percent larger than those in 1967 and the second highest on record. The increase was due almost entirely to larger shipments from Canada, which remained the principal source of foreign peat, supplying 90 percent of the 287,600 tons imported. Practically all of the remainder came from Europe, except for nearly 6,000 tons shipped from Trinidad and Tobago, but imports from Europe declined 29 percent, principally because of the smaller shipments from West Germany. Of the European shipments, West Germany supplied nearly two-thirds of the total, while Ireland, the Netherlands, Poland, and Sweden supplied most of the balance.

Imported peat was classified by use into two grades: Poultry and stable, and fertilizer. Of the total, 99.4 percent was fertilizer grade, which entered the United States duty free. A duty of $0.25 per long ton was levied on poultry-and-stable-grade peat. No data were available on the ultimate uses of the imported peat; presumably, however, poultry and stable grade was used for animal and poultry litter, and fertilizer grade was used in soil improvement.

The bulk of the imports entered the United States through the Ogdensburg and Buffalo, N.Y., Seattle, Wash., St. Albans, Vt., Detroit, Mich., and Pembina, N. Dak. customs districts.

Table 7.—U.S. imports for consumption of peat moss, by kinds and by countries

Country	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967						
Cameroon	-------	------	46	$2	46	$2
Canada	3,272	$172	247,155	10,849	250,427	11,021
Denmark	-------	------	936	30	936	30
Finland	13	1	76	9	89	10
Germany, West	269	13	22,005	890	22,274	903
Ireland	40	2	701	34	741	36
Mexico	7	1	---------	--------	7	1
Netherlands	-------	------	247	10	247	10
Norway	-------	------	64	14	64	14
Poland	-------	------	5,285	209	5,285	209
Sweden	-------	------	726	41	726	41
Total	3,601	189	277,241	12,088	280,842	12,277
1968						
Brazil	-------	------	55	4	55	4
Canada	1,428	87	258,771	11,580	260,199	11,667
Denmark	-------	------	81	5	81	5
Germany, West	259	12	13,439	551	13,698	563
Ireland	38	1	1,024	44	1,062	45
Netherlands	-------	------	459	16	459	16
Poland	-------	------	5,528	228	5,528	228
Sweden	-------	------	579	32	579	32
Switzerland	-------	------	44	2	44	2
Trinidad and Tobago	-------	------	5,821	250	5,821	250
United Kingdom	-------	------	74	4	74	4
Total	1,725	100	285,875	12,716	287,600	12,816

Table 8.—U.S. imports for consumption of peat moss in 1968, by grades and by customs district

Customs district	Poultry and stable grade		Fertilizer grade		Total	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Baltimore, Md	-------	------	1,452	$56	1,452	$56
Boston, Mass	-------	------	705	29	705	29
Bridgeport, Conn	-------	------	20	1	20	1
Buffalo, N.Y	42	$2	28,083	1,250	28,125	1,252
Charleston, S.C	-------	------	363	15	363	15
Chicago, Ill	-------	------	108	5	108	5
Detroit, Mich	181	10	42,405	1,932	42,586	1,942
Duluth, Minn	37	1	1,206	48	1,243	49
Great Falls, Mont	-------	------	7,167	329	7,167	329
Honolulu, Hawaii	14	1	6	(1)	20	1
Houston, Tex	-------	------	873	37	873	37
Los Angeles, Calif	-------	------	3,054	141	3,054	141
Miami, Fla	-------	------	757	35	757	35
Mobile, Ala	-------	------	2,212	86	2,212	86
New Orleans, La	22	1	2,690	105	2,712	106
New York, N.Y	59	2	2,914	148	2,973	150
Norfolk, Va	64	3	1,626	62	1,690	65
Ogdensburg, N.Y	-------	------	66,557	2,738	66,557	2,738
Pembina, N. Dak	1,005	66	16,465	683	17,470	749
Philadelphia, Pa	22	1	1,631	67	1,653	68
Portland, Maine	-------	------	4,089	202	4,089	202
Portland, Ore	56	2	---------	--------	56	2
St. Albans, Vt	106	4	44,345	1,804	44,451	1,808
San Diego, Calif	-------	------	125	4	125	4
San Francisco, Calif	74	4	466	20	540	24
San Juan, P.R	-------	------	127	7	127	7
Savannah, Ga	-------	------	676	26	676	26
Seattle, Wash	43	3	46,278	2,488	46,321	2,491
Tampa, Fla	-------	------	9,475	398	9,475	398
Total	1,725	100	285,875	12,716	287,600	12,816

---

[1] Less than ½ unit.

Table 9.—Peat moss imported from Canada and West Germany for consumption in the United States in 1968, by grades and by customs district

Customs district	Canada				West Germany			
	Poultry and stable grade		Fertilizer grade		Poultry and stable grade		Fertilizer grade	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Baltimore, Md	-------	-----	--------	--------	-----	-----	595	$25
Boston, Mass	-------	-----	36	$2	-----	-----	69	4
Bridgeport, Mass	-------	-----	20	1	-----	-----	--------	-----
Buffalo, N.Y	42	$2	28,083	1,250	-----	-----	--------	-----
Charleston, S.C	-------	-----	--------	--------	-----	-----	363	15
Chicago, Ill	-------	-----	108	5	-----	-----	--------	-----
Detroit, Mich	181	10	42,405	1,932	-----	-----	--------	-----
Duluth, Minn	37	1	1,206	48	-----	-----	--------	-----
Great Falls, Mont	-------	-----	7,167	829	-----	-----	--------	-----
Honolulu, Hawaii	14	1	6	(1)	-----	-----	--------	-----
Houston, Tex	-------	-----	--------	--------	-----	-----	642	27
Los Angeles, Calif	-------	-----	1,720	87	-----	-----	1,217	50
Miami, Fla	-------	-----	--------	--------	-----	-----	593	27
Mobile, Ala	-------	-----	91	3	-----	-----	2,099	82
New Orleans, La	-------	-----	70	4	22	$1	1,355	54
New York, N.Y	-------	-----	--------	--------	21	1	1,207	54
Norfolk, Va	-------	-----	--------	--------	64	3	828	32
Ogdensburg, N.Y	-------	-----	66,557	2,738	-----	-----	--------	-----
Pembina, N. Dak	1,005	66	16,465	683	-----	-----	--------	-----
Philadelphia, Pa	-------	-----	--------	--------	22	1	1,019	48
Portland, Maine	-------	-----	4,089	202	-----	-----	--------	-----
Portland, Ore	-------	-----	--------	--------	56	2	--------	-----
St. Albans, Vt	106	4	44,345	1,804	-----	-----	--------	-----
San Diego, Calif	-------	-----	125	4	-----	-----	--------	-----
San Francisco, Calif	-------	-----	--------	--------	74	4	417	17
San Juan, P.R	-------	-----	--------	--------	-----	-----	113	6
Savannah, Ga	-------	-----	--------	--------	-----	-----	620	24
Seattle, Wash	43	3	46,278	2,488	-----	-----	--------	-----
Tampa, Fla	-------	-----	--------	--------	-----	-----	2,302	91
Total	1,428	87	258,771	11,580	259	12	18,489	551

[1] Less than ½ unit.

WORLD REVIEW

World production of peat in 1968 was estimated at 211 million tons, a decrease of 3.4 percent from estimated production in 1967.

The U.S.S.R. had the largest production, with an estimated output of 209 million tons, about 99 percent of the world total. Peat has long been used as a major source of energy in some areas of the U.S.S.R. It is estimated that about one-third of the production in 1968 was used for fuel. Most of the fuel peat was used for generating electric power; however, sizable quantities were made into briquets for domestic and industrial uses. The major part of the Soviet output was used in agriculture for soil improvement but large quantities of peat were also used in producing peat-mineral-ammonia fertilizers, which are used widely in place of regular animal and chemical fertilizers.

Ireland is the second largest producer of peat, with recent annual production estimated around 5 million tons. Exact data on output in 1968 were not available. Although production was small in comparison with that of the U.S.S.R., peat provided a substantial part of Ireland's energy requirements, both as a household fuel and for generating electric power. A large part of Ireland's production was exported.

Information on the total output of West Germany, the third largest producer, was similarly unavailable, but it was estimated that around one-half million tons of peat was produced for fuel. More than twice this amount probably was produced for agricultural purposes in 1968.

East Germany, the Netherlands, Canada, Finland, and Sweden are the other major world producers, but data on production in some of these countries were not available. All, however, probably produced in excess of 100,000 tons. The United States ranked fourth in world output, which amounted to less than 0.5 percent.

Table 10.—World production of peat, by countries[1]

(Thousand short tons)

Country	1964	1965	1966	1967	1968 ^{p}
Argentina: Fuel	4	4	^{r} 6	2	NA
Canada: Agricultural use	255	288	285	^{r} 281	288
Denmark: Fuel	44	22	11	11	^{e} 6
Finland:					
Agricultural use	NA	NA	^{r} 143	^{r} 137	^{e} 138
Fuel	^{r} 121	^{r} 110	^{e} ^{r} 110	^{e} ^{r} 110	^{e} 110
France: Agricultural use	52	49	^{r} 64	91	NA
Germany, West:					
Agricultural use	1,085	1,156	1,250	^{r} 1,202	NA
Fuel	773	484	524	^{r} 362	NA
Hungary: Agricultural use ^{e}	^{r} 72	^{r} 72	^{r} 72	72	NA
Ireland:					
Agricultural use	26	31	32	41	NA
Fuel	4,208	^{r} 4,077	4,639	5,175	NA
Israel: Agricultural use ^{e}	15	17	22	22	22
Japan ^{e}	^{r} 77	^{r} 77	^{r} 77	77	77
Korea, South: Agricultural use	68	118	83	34	^{e} 33
Netherlands ^{e}	440	440	440	440	440
Norway:					
Agricultural use	10	9	9	^{e} 9	^{e} 9
Fuel	2	2	2	^{e} 2	^{e} 2
Poland: Fuel	110	86	66	45	^{e} 39
Sweden:					
Agricultural use	71	^{r} 98	^{r} 108	^{e} 99	NA
Fuel	158	96	^{r} 96	^{e} 88	NA
U.S.S.R.:					
Agricultural use ^{e}	^{r} 121,254	^{r} 143,300	^{r} 143,300	^{r} 143,300	143,300
Fuel	65,587	^{r} 50,486	72,091	^{r} 66,359	^{e} 66,139
United States: Agricultural use	649	604	611	617	619
Total[2]	^{r} 195,081	^{r} 201,626	^{r} 224,041	^{r} 218,576	211,222
Fuel peat (included in total)	^{r} 71,007	^{r} 55,367	^{r} 77,545	^{r} 72,154	66,296

^{e} Estimate. ^{p} Preliminary. ^{r} Revised. NA Not available.

[1] In addition, Austria, Canada, Iceland, Italy and Spain produced a negligible quantity of fuel peat. No data were available on East Germany, a major producer.

[2] Total is of listed figures only.

TECHNOLOGY

A British patent describes a method whereby the combustion of carbonaceous solid fuels is improved by depositing on its accessible surfaces a copper compound that is convertible during normal combustion to a nonstoichiometric copper oxide up to 800°.[2] The method may be used with raw coal, coke, carbonized coal, or peat. The amount of copper compound used ranges from 0.05 to 2.5 percent by weight of the dry solid fuel, but for economic reasons the amount is generally restricted to 0.10 percent and preferably to 0.075 percent. The compounds used are copper sulfate, copper oxide, copper hydroxide, or copper naphthenate. The solution is sprayed on the fuel at or above atmospheric pressure as it moves along a conveyor.

Another British patent was issued in May 1968 which deals with the use of peat in soil amendments.[3] The process comprises heating a mixture of 100 parts of aqueous, fermentation-spent liquor and from 20 to 60 parts of peat having a pH factor more than 6 with an amount of calcium greater than the base-exchange capacity of the peat. The heating temperature is ordinarily from 100° to 120° in a closed vessel. The calcium is added in the form of lime or calcium carbonate in order to increase the pH factor and to permit a greater release of inorganic nitrogen. The mixture of spent liquor and peat contains ammonia in an amount not greater than the base-exchange capacity of the peat. The liquor may come from alcoholic fermentation or preparation of an amino acid, antibiotic, vitamin, or substance related to nucleic acid. Peat has a strong capacity to absorb cations which are useful as plant nutrients and to aid filtration in fixing or absorbing insoluble fractions in fermentation-spent liquors.

---

[2] Wilkinson, Herbert C., and Herbert E. Blayden, (British Coke Research Association). Carbonaceous Solid Fuel Having Improved Combustion Properties. British Pat. 1,069,288, May 17, 1967; Chem. Abs., v. 69, No. 4, July 22, 1968. col. 11996e

[3] Kyowa Fermentation Industry Co., Ltd. Peat in Soil Amendments. British Pat. 1,111,798, May 1, 1968; Chem. Abs., v. 69, No. 3, July 15, 1968, col. 9976e.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/187

Perlite

By William C. Henkes [1]

Domestic production of crude perlite in 1968 was 12.5 percent lower than the 638,000 tons produced in 1967. The total quantity sold or used, however, increased 3.6 percent over that of the previous year. Output of expanded perlite was 3.1 percent higher than that of 1967; quantity sold or used increased 2.9 percent, but its value increased only 1.0 percent.

DOMESTIC PRODUCTION

In 1968, 14 companies operated 19 mines. Producers used in their own plants 225,585 tons of crude perlite, nearly 3,000 tons more than in 1967; the quantity sold to expanders was approximately 12,000 tons more than during the previous year.

With an output of 491,783 tons, New Mexico produced 88 percent of the total domestic crude perlite. Arizona ranked second. Other producing States, in descending order of production, were Nevada, California, Colorado, Idaho, and Oregon. Texas and Utah reported no production in 1968.

During the year 73 companies produced expanded perlite at 86 plants, a decrease of five companies and five plants. Output was 11,320 tons greater than the 351,160 tons (revised) produced in 1967. The Kaiser Gypsum Co., Inc., plant in Seattle, Wash., and the Virginia Perlite Corp. plant in Hopewell, Va., did not produce expanded perlite during the year, thereby reducing the number of producing States to 31. California had nine companies with nine operating plants, Illinois had seven companies and seven plants, and Texas had six companies and six plants. Illinois was the leading State in output, followed by Mississippi, California, and Texas.

In August, Pickands Mather & Co., Cleveland, Ohio, announced its purchase of the Johns-Manville Perlite Corp. plant at Joliet, Ill. The plant was originally designed to process perlite as well as bentonite, vermiculite, and bauxite; it occupies a 6-acre tract along the Illinois barge canal, has several grinding circuits, expansion and blending equipment, and 50,000 square feet of warehouse space.[2]

Table 1.—Crude and expanded perlite produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Crude perlite						Expanded perlite		
	Quantity mined	Sold		Used at own plant to make expanded material		Total quantity sold and used	Quantity produced	Sold or used	
		Quantity	Value	Quantity	Value			Quantity	Value
1964	427	211	$1,845	139	$1,228	350	320	319	$14,533
1965	502	231	1,731	161	1,621	392	348	344	15,391
1966	548	193	1,799	211	2,108	404	394	394	16,408
1967	638	190	1,802	223	2,171	413	351	350	15,115
1968	558	202	1,975	226	2,246	428	362	360	15,265

---

[1] Petroleum engineer, Bureau of Mines, Denver, Colo.

[2] Mining Engineering. V. 20, No. 8, August 1968, pp. 12–13.

Table 2.—Expanded perlite produced and sold by producers in the United States

State	1967				1968			
	Quantity produced (short tons)	Sold or used			Quantity produced (short tons)	Sold or used		
		Quantity (short tons)	Value (thousands)	Average value per ton		Quantity (short tons)	Value (thousands)	Average value per ton
California	17,630	18,020	$1,223	$67.87	39,270	39,360	$1,116	$28.36
Florida	8,720	7,900	539	68.23	9,700	8,590	598	69.63
Illinois	(1)	(1)	2,660	(1)	(1)	(1)	2,919	(1)
Kansas	880	880	67	76.14	900	930	80	86.42
Maryland	7,890	6,700	(1)	(1)	7,080	6,820	457	72.39
New Jersey	5,590	6,320	381	60.28	(1)	(1)	(1)	(1)
New York	6,180	6,200	375	60.48	5,120	5,120	295	57.52
Ohio	9,290	9,290	728	78.36	7,750	7,750	(1)	(1)
Oregon	470	470	(2)	(2)	540	540	40	74.37
Pennsylvania	13,100	13,070	959	73.37	12,170	12,290	869	70.68
Texas	39,690	39,600	2,329	58.81	(2)	(2)	(2)	(2)
Other Eastern States [3]	r 187,640	r 187,550	3,976	r 34.16	193,840	193,210	4,756	[4] 38.20
Other Western States [5]	54,080	53,550	1,878	35.07	86,110	86,330	4,134	47.89
Total [6]	r 351,160	r 349,540	15,115	r 42.24	362,480	360,430	15,265	42.35

r Revised.

[1] Included with "Other Eastern States."

[2] Included with "Other Western States."

[3] Includes Georgia, Illinois (1967, 1968 quantity), Indiana, Kentucky, Maryland (1967 value), Massachusetts, Michigan, Mississippi, New Hampshire, New Jersey (1968), North Carolina, Ohio (1968 value), Tennessee, Virginia (1967), and Wisconsin.

[4] Based on quantity of 200,960 tons (193,210 "Other Eastern States" plus 7,750 from Ohio) and value of $7,675,820 ($4,756,120 "Other Eastern States" plus $2,919,200 for Illinois).

[5] Includes Arizona, Colorado, Idaho, Iowa, Louisiana, Minnesota, Missouri, Nebraska, Nevada, Oregon (1967 value), Texas (1968), Utah, and Washington (1967).

[6] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Consumption and uses of expanded perlite as reported by the producers are shown in table 3. Insulation board and building plasters continued to be the principal uses for this commodity. Among the "Other uses" are refractories, roof insulation, texturing, cryogenics, and paint additives. During the year, numerous U.S. and foreign patents were issued for processes involving perlite; most of them were for refractory, insulation, and agricultural use.

PRICES

The average value of crude perlite sold to expanders was $9.78 per ton, $0.30 per ton higher than in 1967. Crude perlite used by producers in their own plants was valued at $9.95 per ton compared with $9.74 per ton in 1967. The average value of crude perlite sold and used was $9.87 per ton, $0.25 higher than in 1967.

Expanded perlite was valued at an average of $42.35 per ton compared with $42.24 in 1967. Values, however, ranged from $22.25 to $99.47 per ton.

Table 3.—Consumption and end-uses of expanded perlite

(Percent)

Use	1967	1968
Insulation board	(1)	34
Building plaster	31	23
Filter aid	18	19
Concrete aggregate	8	9
Loose fill insulation	5	3
Soil conditioning	3	3
Filler	2	2
Filter	--	(2)
Other	33	7

[1] Included in "Other."

[2] Less than 0.5 percent.

WORLD REVIEW

Czechoslovakia.—An expanded perlite plant is scheduled to be built at Malesica, near Prague, by the company, Keramicke Zavody Kosice. Using crude perlite imported from the Soviet Union, the plant will have an annual capacity of 75,000 cubic meters of expanded perlite, when operations commence in 1970.[3]

Greece.—Production of crude perlite in Greece in 1968 was 142,200 tons.[4]

Mexico.—In 1968 Mexico reported perlite production of 10,945 tons valued at $39,700[5] compared with 11,654 tons in 1967; 1966 output was 11,128 tons.[6]

United Kingdom.—Output of perlite in Northern Ireland in 1968 was 78 tons valued at $125;[7] comparable figures for 1967 were 130 tons valued at $272.[8] Johns-Manville Co. Ltd., at its plant at Hessle, near Hull, produced expanded perlite aggregates in particle sizes ranging from 0.01 inch to 1/8 inch. The products, used in a wide variety of insulation needs, were manufactured from crude perlite imported from Greece.[9]

---

[3] Industrial Minerals (London). No. 14, November 1968, p. 31.

[4] U.S. Embassy, Athens, Greece. State Dept. Airgram A-166, May 3, 1969, p. 3, encl. 1.

[5] Converted at the rate of 1 Mexican peso (Mex. $) equals U.S. $0.08.

[6] U.S. Embassy, Mexico, D. F., Mexico. State Dept. Airgram A-250, May 8, 1969, p. 6, encl. 1.

[7] Converted at the rate of 1 pound (£) equals US$2.40.

[8] U.S. Consulate, Belfast, North Ireland. State Dept. Airgram A-27, Mar. 26, 1969, p. 2, encl. 1. Value conversion for 1967 was at the rate of £1 = US$2.80.

[9] Industrial Minerals (London). No. 3, December 1967, p. 28.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/9

Crude Petroleum and Petroleum Products

By James G. Kirby [1] and Betty M. Moore [2]

The 5.8-percent gain in the demand for petroleum in 1968 was the highest on record since 1955. The total demand [3] for all oils averaged 13,314,000 barrels daily with domestic demand increasing 804,000 barrels daily, or 6.5 percent. Even the export market for petroleum showed surprising strength. Although below the high 1967 level resulting from the Suez crisis, exports were above the normal trend. Crude oil production in the United States averaged 9,096,000 barrels daily, a gain of 286,000 barrels daily.

While the gain in production was not unusually high, the significant difference was that Alaska and California accounted for half of the increase. Alaska also received prominence during 1968 when huge reserves of petroleum were discovered on the north slope adjacent to the Arctic Ocean. Estimates of the potential of these reserves range from 5 to 10 billion barrels of crude oil. Studies are underway to determine methods of getting this oil to the consuming markets under the severe hardships created by the Arctic weather.

Demand by Product.—*Gasoline.*—The 6.4-percent increase in the domestic demand for motor gasoline in 1968 offset the lower increase of 1967 and restored the normal growth trend to 4 percent. Although the changeover from propeller driven (gasoline fueled) aircraft to jet aircraft is about completed by the commercial airlines; it is still continuing in private fleets operated by companies. The decrease in demand for aviation gasoline was only 7.8 percent compared with 14.3 percent in 1967.

Distillate Fuel Oil.—January, February, and December are the highest demand months for distillate fuel oil, and all three were much colder than normal in 1968. Along with this was the 4.4-percent growth in industrial activity in 1968, resulting in a 5.1-percent increase in the domestic demand for distillate fuel oil. The relaxing of import controls on No. 4 distillate fuel oil permitted this fuel to be substituted for residual fuel oil in east coast areas where sulfur content of fuels is restricted.

Residual Fuel Oil.—The 4.0-percent increase in domestic demand for residual fuel oil was due to increased use by the electric utilities. Colder than normal weather and increased industrial activity usually benefit both residual fuel oil and distillate fuel oil. Natural gas and distillate fuel oils apparently made inroads into the industrial and heating oil markets for residual fuel oil in areas where air pollution control limits sulfur content of fuels. The total demand for residual fuel oil in 1968 was 1,912,000 barrels daily including exports of 54,000 barrels daily and domestic demand of 1,858,000 barrels daily.

Kerosine.—The domestic demand for

---

[1] Industry economist, Division of Mineral Studies.

[2] Statistical assistant, Division of Statistics.

[3] Certain terms used in this chapter are more or less unique to the petroleum industry. Principal terms and their meaning are—

Total demand.—A derived figure representing total new supply plus decreases or minus increases in reported stocks. Because there are substantial secondary and consumers' stocks that are not reported to the Bureau of Mines, this figure varies considerably from consumption.

Domestic demand.—Total demand less exports.

New supply of all oils.—The sum of crude oil production plus production of natural gas liquids, plus benzol (coke-oven) used for motor fuel and other hydrogens, plus imports of crude oil and other petroleum products.

Transfers.—Crude oil conveyed to fuel-oil stocks without processing, or reclassification of products from one product category to another.

All oils.—Crude petroleum, natural gas liquids, and their derivatives.

Table 1.—Salient statistics of crude petroleum, refined products, and natural gas liquids in the United States

(Thousand 42-gallon barrels unless otherwise indicated)

	1964	1965	1966	1967	1968 p
Crude petroleum:					
Domestic production (including lease condensate)	2,786,822	2,848,514	3,027,763	3,215,742	3,329,042
World production	10,311,134	11,058,462	12,019,964	12,873,486	14,083,717
U.S. proportion ______ percent	27	26	25	25	24
Exports [1]	1,363	1,097	1,477	r 26,541	1,802
Imports [2]	438,643	452,040	447,120	411,649	472,323
Stocks, yearend	230,057	220,289	238,391	248,970	272,193
Runs to stills	3,223,329	3,300,842	3,447,193	3,582,594	3,774,360
Value of domestic product at wells:					
Total ______ thousands	$8,017,078	$8,158,298	$8,726,423	$9,375,727	$9,794,826
Average per barrel	$2.88	$2.86	$2.88	$2.92	$2.94
Total producing oil wells Dec. 31	588,225	589,203	583,302	r 565,289	553,920
Total oil wells completed during year (successful wells)	20,620	18,761	16,780	15,329	14,342
Refined products:					
Exports [1]	72,516	67,191	70,923	r 85,519	83,379
Imports [3]	388,093	448,732	492,042	r 514,342	566,074
Stocks, yearend [4]	573,499	580,188	602,291	r 629,399	649,439
Completed refineries, end of year	300	286	281	291	NA
Daily crude-oil capacity	10,775	10,493	10,760	11,583	NA
Natural gas liquids:					
Production	422,471	441,556	468,635	514,456	550,311
Stocks, end of year	35,679	35,867	40,423	65,742	77,940
All oils:					
Total demand	4,032,382	4,193,746	4,397,469	r 4,593,270	4,872,804
Exports	73,879	68,288	72,400	r 112,060	85,181
Domestic demand	3,958,503	4,125,458	4,325,069	4,481,210	4,787,623

p Preliminary (except for crude production and value). r Revised. NA Not available.

[1] U.S. Department of Commerce data.

[2] Bureau of Mines data for crude oil and unfinished oils.

[3] U.S. Department of Commerce data, except for unfinished oils.

[4] Stocks of refined products also include stocks of unfinished oils, natural gasoline, plant condensate, and isopentane.

kerosine averaged 282,000 barrels daily in 1968, an increase of 2.9 percent. This was the highest demand for kerosine for use other than as jet fuel since 1959.

Jet Fuels.—While the increase in the demand for jet fuels was not as high as in 1967, it amounted to 128,000 barrels daily, or 15.5 percent. The demand for naphtha-type jet, which is generally used by the military, averaged 346,000 barrels daily, an increase of 13.4 percent, while the demand for kerosine-type jet was 606,000 barrels daily, up 16.8 percent from 1967.

Liquefied Gases.—The total demand for liquefied gases in 1968, including that used for fuel and chemicals, was 1,083,000 barrels daily and included exports of 29,000 barrels daily. More detail on liquefied gases can be found in the Natural Gas Liquids Chapter.

Other Products.—The total demand for all other products including crude oil exports and losses and refinery overage in 1968 averaged 1,366,000 barrels daily, an increase for the year of only 1.2 percent. Domestic demand increased 6.6 percent, but crude oil exports returned to the usual level of 5,000 barrels daily in 1968 in contrast to the level of 73,000 barrels daily that resulted from the Middle East crisis in 1967. The total demand for miscellaneous oil, which includes various specialty oils, increased 11.8 percent to 18.9 million barrels; petrochemical feedstock demand was up 10.1 percent despite a decline in exports; the increased industrial activity during 1968 spurred the demand for special naphthas upward by 8.2 percent and lubricating oils, 5.8 percent. There were no delays in the release of Federal funds for interstate highway construction such as occurred in 1967 so that the demand for asphalt and road oil increased 7.2 percent in 1968 compared with a 2.2-percent decline in 1967. Despite a decline in the export market, the demand for wax increased 7.0 percent in 1968. Refinery use as fuel accounted for 57 percent of the total demand for petroleum coke in 1968 and was 3.7 percent higher than in 1967; exports, which represent 20 percent of the demand, increased 19.8 percent in 1968, while other uses for petroleum coke declined 3.2 percent. The demand for petrochemical feedstocks continued to increase rapidly during 1968, with a gain of 10.1 percent for the year. Refineries utilized 149,796,000 barrels of still gas for fuel in 1968 and had a refinery overage of 116,691,000 barrels.

Shipments to U.S. Territories and Possessions.—Domestic demand, as defined in this chapter, refers to demand in all States of the United States. Shipments from the United States to its territories and possessions are included with exports and shipments from territories and possessions to the United States are included in imports. Imports into and exports from territories and possessions are not included in the foreign trade data contained in this chapter.

Scope of Report.—The data presented in this chapter are limited to the United States to permit a breakdown and balancing of supply and demand of operations by States and districts. The composition of the districts used by the Bureau of Mines is explained in the next section.

The increasing volume of natural gas liquids recovered from natural gas has made it desirable to present data on these liquids with crude oil data, as these liquids are blended with refinery products and are similar to materials recovered from refinery gases. These natural gas liquids are recovered at natural-gas processing plants, away from the oil refineries.

The Bureau of mines uses crude-oil production data compiled by State agencies for those States which compile the information. Where such data are not available, monthly questionnaires are sent to all pipeline companies operating within the State. The crude production figure includes field condensate.

Individual refineries reported monthly receipts, input, stocks at the beginning and end of the month, refinery production, and

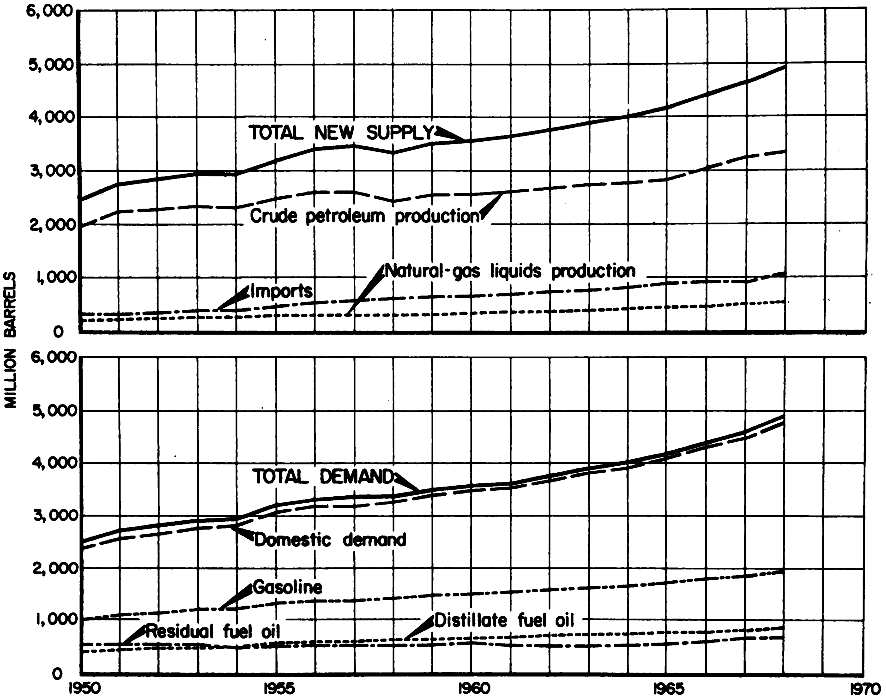

Figure 1.—Supply and demand of all oils in the United States.

deliveries. Data are collected on both product stocks at refineries and pipeline and bulk terminal stocks.

Annual canvasses and State agencies provide supplemental information on the value of crude petroleum at wells, the number of producing wells, sales of fuel oils, asphalt and road oils by uses, and refinery capacity.

The table showing world crude oil production by countries is based on reports from companies operating in these countries, on reports published by these countries, or on data supplied by the U.S. Department of State.

Districts.—The Bureau of Mines reports production of crude petroleum and natural gas liquids and the number of wells drilled by States, with data for Louisiana, New Mexico, and Texas also reported by districts.

New Mexico has two widely separated producing areas. The Southeastern district comprises mainly Lea, Eddy, Chaves, and Roosevelt Counties. The Northwestern district comprises mainly San Juan, Rio Arriba, Sandoval, and McKinley Counties.

The Bureau of Mines producing districts in Texas correspond, with one exception, to grouping of the Texas Railroad Commission districts:

Bureau of Mines districts	*Railroad commission districts*
Gulf Coast	Nos. 2 and 3
West Texas	Nos. 7C, 8 and 8a
East Proper	Part of No. 6 (East Texas field in Cherokee, Smith, Upshur, Rush, and Gregg)
Panhandle	No. 10
Rest of State:	
North	Nos. 7B and 9
Central	No. 1
South	No. 4
Other East Texas	Nos. 5 and 6 (exclusive of East Proper)

Separate production data are shown for the Louisiana Gulf Coast, including the offshore area.

The Bureau of Mines groups refinery operations into another set of districts called refining districts. These refining districts correspond with the grouping originated by the Petroleum Administration for War during World War II and called PAW districts (later changed to PAD districts).

PAD district — *Refining districts*

I—*East Coast*—District of Columbia and Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New Jersey, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia, and Florida, and the following counties of New York: Cayuga, Tompkins, Chemung, and all counties east and north thereof; and the following counties of Pennsylvania: Bradford, Sullivan, Columbia, Montour, Northumberland, Dauphin, York, and all counties east thereof.

PAD district

I—*Appalachian No. 1*—West Virginia and those parts of Pennsylvania and New York not included in the East Coast district.

II—*Appalachian No. 2*—The following counties of Ohio: Erie, Huron, Crawford, Marion, Delaware, Franklin, Pickaway, Ross, Pike, Scioto, and all counties east thereof.

II—*Indiana-Illinois-Kentucky*—Indiana, Illinois, Kentucky, Tennessee, Michigan, and that part of Ohio not included in the Appalachian district.

II—*Oklahoma-Kansas-Missouri*—Oklahoma, Kansas, Missouri, Nebraska, and Iowa.

II—*Minnesota-Wisconsin-North Dakota-South Dakota*—Minnesota, Wisconsin, North Dakota, and South Dakota.

III—*Texas Inland*—Texas, except Texas Gulf Coast district.

PAD district *Refining districts* (con't)

III—*Texas Gulf Coast*—The following counties of Texas: Newton, Orange, Jefferson, Jasper, Tyler, Hardin, Liberty, Chambers, Polk, San Jacinto, Montgomery, Harris, Galveston, Waller, Fort Bend, Brazoria, Wharton, Matagorda, Jackson, Victoria, Calhoun, Refugio, Aransas, San Patricio, Nueces, Kleberg, Kenedy, Willacy, and Cameron.

III—*Louisiana Gulf Coast*—The following parishes of Louisiana: Vernon, Rapides, Avoyelles, Pointe Coupee, West Feliciana, East Feliciana, Tangipahoa, St. Helena, Washington, and all parishes south thereof; the following counties of Mississippi: Pearl River, Stone, George, Hancock, Harrison, and Jackson; and Mobile and Baldwin Counties, Ala.

III—*North Louisiana-Arkansas*—Arkansas and those parts of Louisiana, Mississippi, and Alabama not included in the Louisiana Gulf Coast district.

III—*New Mexico*—New Mexico.

IV—*Rocky Mountain*—Montana, Idaho, Wyoming, Utah, and Colorado.

V—*West Coast*—Washington, Oregon, California, Nevada, Alaska, Arizona, and Hawaii.

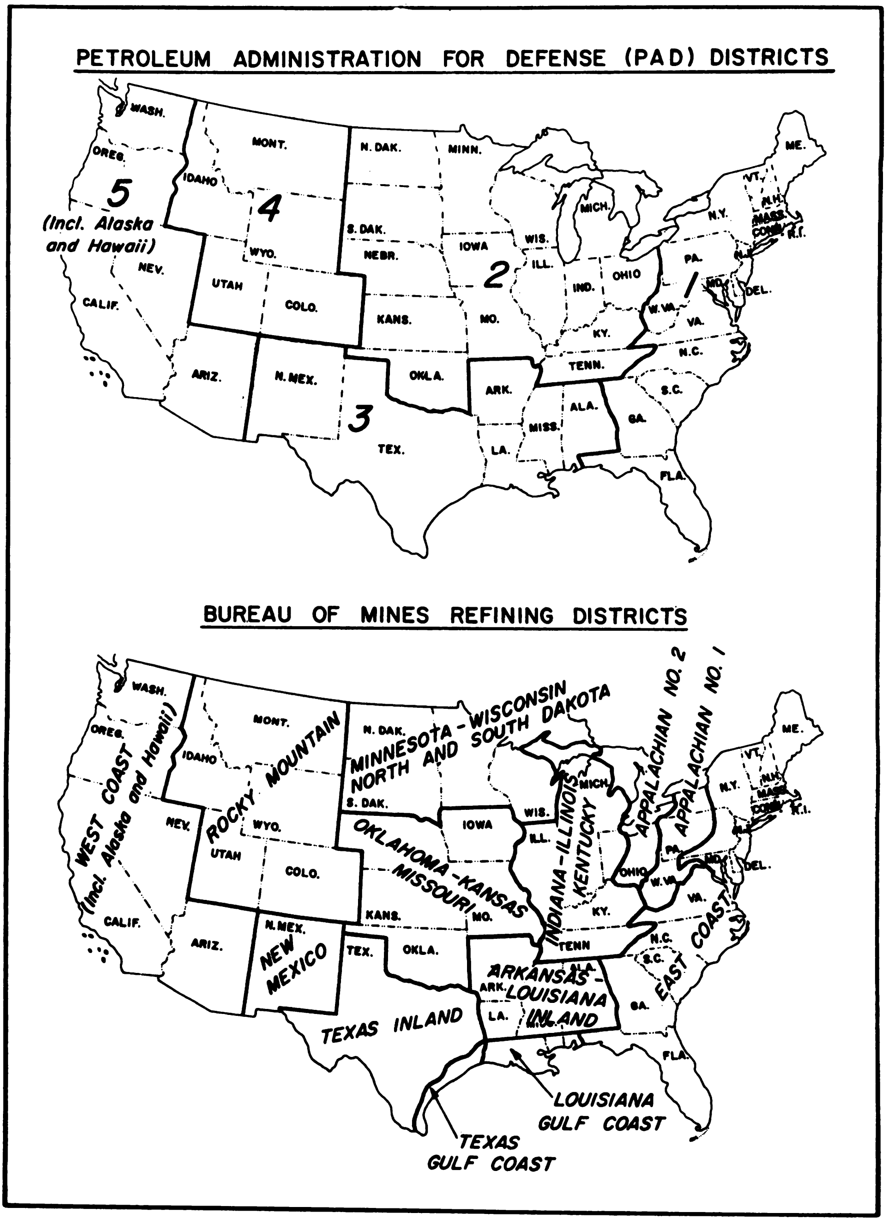

Figure 2.—Map of PAD Districts and Bureau of Mines Refining Districts.

CRUDE PETROLEUM

PRODUCTION

Crude oil production in the United States in 1968 was 3,329,042,000 barrels, 113,300,000 barrels above the 1967 level.

There was a heavy demand for domestic crude oil during the first 4 months of 1968 when scheduling of overseas imports of crude oil was delayed in the hope that shipping rates would be lowered to the pre-Middle East crisis level. Later, to avoid the loss of their import licenses, some of which expired July 31, refiners increased their imports. The high level of production continued through August and with the high imports, crude stocks built up. Production was cut back in September and remained at a low level through the balance of the year. Only two States reported gains in production in excess of 100,000 barrels daily. They were Louisiana, with an increase of 117,000 barrels daily, and Alaska with 101,000 barrels. Additional data on crude oil production, by States, can be found in Volume III of the 1968 Minerals Yearbook.

CONSUMPTION

The total demand for crude oil in the United States in 1968 averaged 10.3 million barrels daily, of which domestic crude oil supplied 9.0 million barrels and foreign crude oil 1.3 million barrels. The demand for crude oil increased 4.1 percent with the demand for domestic crude oil increasing 2.9 percent and that for foreign crude oil increasing 13.8 percent.

Runs to Stills.—Crude runs to stills averaged 10,312,000 barrels daily in 1968 compared with 9,815,000 barrels daily in 1967.

Demand by States of Origin.—Distribution of domestic crude oil by refining States

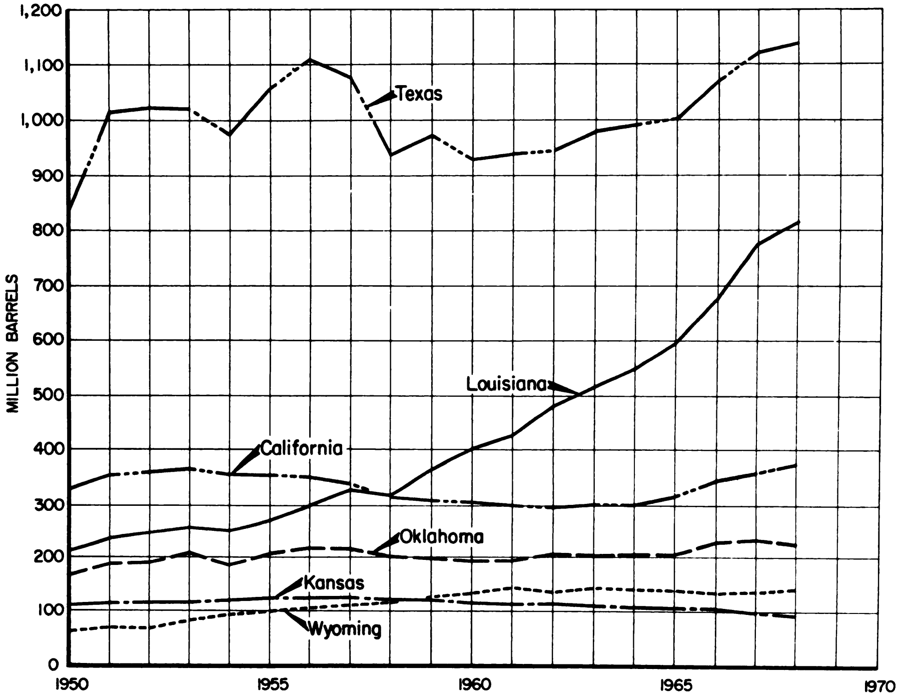

Figure 3.—Production of crude petroleum in the United States, by principal producing States.

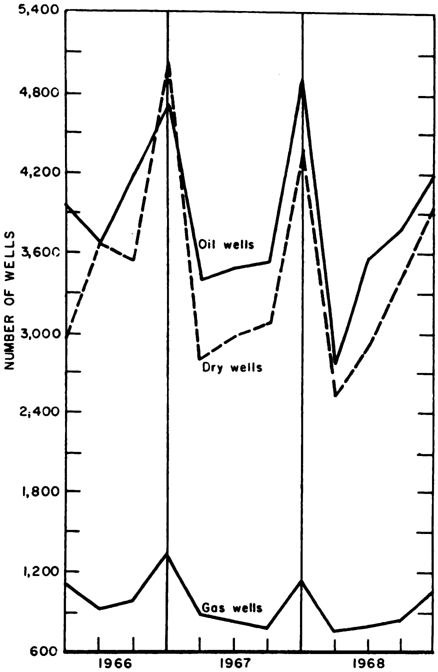

Figure 4.—Wells drilled for oil and gas in the United States, by months.

and districts can be analyzed from receipts of crude oil at refineries. When long-distance shipments are involved, various crude oils may be mixed in transit or storage and identification by origin may be only approximate.

SUPPLY AND DISTRIBUTION

The total crude oil needed to meet demand requirements in 1968 was 3,785 million barrels. Crude oil production, after adjustment for a stock increase, accounted for 3,311 million barrels, and imported crude oil, adjusted for a stock increase, accounted for 467 million barrels. The difference, 7 million barrels, was classed as "unaccounted for" crude oil.

In previous years, the Bureau has adjusted supply or demand data for crude oil to obtain a balance. While these adjustments were made in either production or consumption items, the difference could also have been in the reported stocks. To avoid making this arbitrary adjustment, data for 1968 and future reports will carry an item in supply called "unaccounted for crude oil."

PRODUCTIVE CAPACITY

According to the American Petroleum Institute, the maximum crude oil production that could be attained in the United States as of January 1, 1969, was 12.1 million barrels daily. This is based on the assumption that such production could be achieved in 90 days with existing wells, well equipment, and present surface facilities plus work changes that could be accomplished within that time period.

WELLS

Continuing the downward trend, 1,613 fewer wells were drilled in 1968 than in 1967. The total number of wells drilled in 1968 excluding service wells was 30,621 compared with 32,234 in 1967. Ten States reported increased drilling activity in 1968; however, the only States with sizable increases were Montana with 311 additional wells drilled, Louisiana with 297, and

Wyoming with 267. Texas reported 1,522 fewer wells drilled, and in Kansas, drilling was off by 172 wells. Offshore wells drilled increased from 1,044 in 1967 to 1,433 in 1968. The total footage drilled in 1968 was 144,970,447 feet, a gain of 2.6 percent for the year. The average footage drilled per well in 1968 was 4,738 feet compared with 4,384 feet in 1967. The approximate number of producing oil wells as of December 31, 1968, was 553,920.

RESERVES

The American Petroleum Institute Committee on Petroleum Reserves estimated proved reserves of crude oil as of December 31, 1968, to be 30,707 million barrels, a decrease of 670 million barrels for the year. Texas reported a decline of 684 million barrels, while in Louisiana, reserves increased 152 million. The Rocky Mountain States improved their crude oil reserve position with the addition of 80 million barrels in Colorado, 57 million in Wyoming, and 37 million in Montana.

The estimate of crude-oil reserves included only oil recoverable under existing economic and operating conditions.

During 1968, potential large reserves of crude oil were discovered on the north slope of Alaska which have been estimated as having a potential of 5 to 10 billion barrels. However, the API reserves committee did not have sufficient information to make a meaningful determination of "proved" reserves associated with these discoveries.

REFINED PRODUCTS

Almost 90 percent of the demand for petroleum products is for fuel and power, and the balance is used as the base stock in the manufacturing of several other products. Petroleum products used in the transportation field account for 55 percent of domestic product demand, and include, in the order of importance, gasoline, jet fuels, distillate fuel oils, residual fuel oil, liquefied gases, and lubricating oils.

Gasoline is consumed principally in highway transport, aviation, mechanized farming and power boating. Kerosine (other than the straight-run kerosine used as fuel in commercial jet aircraft) is used primarily in space heaters, as range oil, or for farm equipment. Distillate fuel oils, which include the light diesel fuels, are used, for space heating, locomotive fuel, industrial use, vessel use, and by the military. Residual fuel oil is used primarily in electric utilities and for heavy-fuel use. Residual fuels usually sell for less than crude oil at the refineries. As they are not normally moved by pipeline, distribution depends on low-cost water transportation and limited tank movement.

Liquefied gases, in competition with kerosine and light distillate fuel oil for domestic use, are used as fuel in internal-combustion engines and are becoming increasingly important as the initial raw material in the development of many petrochemicals.

The total demand for all oils averaged 13,314,000 barrels daily in 1968, including a domestic demand for 13,081,000 barrels daily and exports of 233,000 barrels daily. On a percentage basis, total demand increased 5.8 percent, domestic demand increased 6.5 percent, and exports declined 24.1 percent.

The new supply of refined products comes from crude oil processed at refineries, natural gas liquids, and imports of products from foreign companies. The new supply exceeded demand, resulting in an increase of 32,238,000 barrels to stocks of refined products.

GASOLINE

The domestic demand for motor gasoline in 1968 averaged 5,260,000 barrels daily, a gain of 6.1 percent for the year. Aviation gasoline continued to lose domestic markets to jet fuel, but the decline was only 7.6 percent, compared with 14.3 percent in 1967 and 11.7 percent in 1966. Aviation gasoline is also losing out in the export markets.

The new supply of motor gasoline in 1968 was 1,930 million barrels, of which 1,643 million was produced from crude oil, 265 million was from natural gas liquids, and 22 million was imported.

Although District III is the principal producer of motor gasoline, it consumes only 12.9 percent of the U.S. total, the balance being shipped to other districts.

District II is the largest consuming area, using 34.9 percent, and is closely followed by District I, which uses 34.5 percent. The total consumption figure, 1,923.2 million barrels, is from data compiled by the American Petroleum Institute based on tax data reported to the States. This differs from the domestic demand data compiled by the Bureau of Mines because of stock changes in secondary storage facilities which are not included in the Bureau's data.

KEROSINE

Kerosine demand, exclusive of that used as commercial jet fuel, rallied in 1968 and rose 2.9 percent. Demand in 1968 averaged 282,000 barrels daily, compared with 274,000 barrels daily in 1967. Undoubtedly, the colder weather during the first and fourth quarters was responsible for the increase since all of the gain occurred in these quarters. Most of the additional demand requirements were met by a reduction in stocks, and at the close of the year stocks were reduced to 23.5 million barrels. This was the lowest closing stock level since December 31, 1950.

DISTILLATE FUEL OIL

The domestic demand for distillate fuel oil in 1968 averaged 2,357,000 barrels daily, a gain of 5.1 percent. Several factors contributed to the high growth rate, including colder than normal weather during January, February, and December, increased industrial activity, and the relaxation of import controls for No. 4 fuel oil. No. 4 fuel oil, being a low-sulfur-content fuel oil, can be substituted in areas where restrictions have been placed on the use of residual fuel oils of high sulfur content.

Stocks of distillate fuel oil built up rapidly during the second and third quarters of 1968, and by August they were 33.5 million barrels above those of August 1967. Refiners cut back on production by reducing the yields, and at yearend stocks were

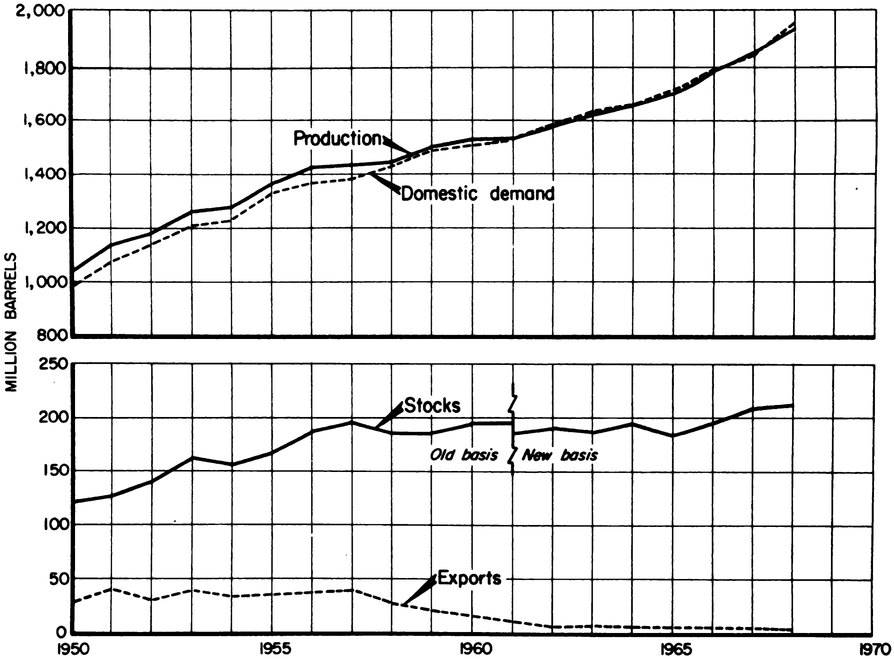

Figure 5.—Production, domestic demand, stocks, and exports of gasoline in the United States.

down to 173.2 million barrels, only 13.5 million barrels above the December 31, 1967, level.

RESIDUAL FUEL OIL

The growth in the domestic demand for residual fuel oil in 1968 was in the east and west coast markets and averaged 72,000 barrels daily. Residual fuel oil use by electric utilities in District I increased 64,000 barrels daily, offsetting the loss in the other use categories of 6,000 barrels daily. In Districts II–IV, demand declined 7,000 barrels daily, while electric utility use increased 4,000 barrels daily. Demand increased 20,000 barrels daily in District V, 3,000 barrels were attributed to growth in electric utility use, vessel bunkering increased 8,000 barrels daily, military use was up 3,000 barrels daily, and heating and industrial use accounted for the balance.

The new domestic supply of residual fuel oil remained about 765,000 barrels daily, and imports increased 67,000 barrels daily to 1,152,000 barrels. Apparently, utility companies on the east coast were able to contract for imported residual fuel oil with sulfur content low enough to meet regulations of certain States, counties, and cities since they did not curb their use of residual. Two large Caribbean refineries are constructing desulfurization units which will make available additional supplies of low-sulfur residual fuel oil for the east coast markets.

JET FUELS

The growth in demand for jet fuels continued at a rapid pace during 1968. Domestic demand was 952,000 barrels daily, an increase of 15.5 percent. According to a Bureau of Mines annual survey, shipments of jet fuel for commercial use averaged 561,000 barrels daily, an increase of 16.4 percent, and shipments for military use, including direct imports, averaged 398,000 barrels daily, a gain of 11.2 percent. The refiners are not able in some instances to identify end use, and some kerosine eventually is sold in the kerosine-type jet market.

Imports of jet fuel averaged 102,000 barrels daily, this includes 90,000 barrels daily imported in bond for use by aircraft engaged in flights with destinations outside the United States. There are no custom duties on these imports, and bonded imports of such fuels are not subject to import control regulations.

LUBRICANTS

Offsetting the poor showing for 1967, the total demand for lubricants increased 5.8 percent in 1968 to 66.5 million barrels. Exports declined slightly in 1968, but domestic demand increased from 44.1 million barrels to 48.3 million barrels. According to a sales survey by the Bureau of the Census, 55 percent of lubricating oil and grease sales in 1967 were industrial-type lubricants, and 45 percent were automotive and aviation type.

LIQUEFIED GASES, ETHANE, AND ETHYLENE

Liquefied gases are derived from two sources. Those produced at refineries are called liquefied refinery gases to distinguish them from liquefied petroleum gases produced from natural gas. The liquefied petroleum gases (LPG) are all saturated (propane, butane, etc.). The liquefied refinery gases (LRG) may contain unsaturated compounds or olefins (propylene, butylene, etc.). The olefins are used as feedstocks for chemical plants. The saturated gases may be used as chemical raw materials or as fuel. Separate data are collected on liquefied refinery gas used as fuel and that used as raw material for petrochemical feedstocks. Liquefied gases are also used in producing gasoline and are reported in this chapter as natural gas liquids at refineries or as gasoline. Although ethane and ethylene are not defined as liquefied gases, the statistics on these products are in some cases reported with those of LPG and LRG.

The total demand for liquefied gases in 1968, exclusive of that blended into other products at refineries or terminals, was 396,349,000 barrels. This includes a domestic demand of 385,741,000 barrels and exports of 10,608,000 barrels.

More detailed information on liquefied gases may be found in the chapter on natural gas liquids.

ASPHALT AND ROAD OIL

There was no delay in Federal funds for interstate highway construction programs such as occurred in 1967, and new building construction increased substantially, resulting in a 7.2-percent increase in domestic demand for petroleum asphalt, and road oil. Shipments of asphalt products for 1968 increased 10.1 percent, with roofing products up 20.2 percent and paving products up 9.7 percent. The shipment data include, in addition to the refinery production and imports, various emulsifiers and blenders. Total shipments for consumption in the United States in 1968 were 28,379,000 short tons.

OTHER PRODUCTS

Special Naphthas.—The total demand for special naphthas was 29.4 million barrels in 1968, an increase of 8.2 percent. This product is used primarily for paint thinners, cleaning agents, and solvents.

Waxes.—Although exports of petroleum waxes continued to decline, domestic demand increased 12.7 percent, resulting in a 7.0-percent rise in total demand to 5,948,000 barrels. About 26 percent of the domestic demand for wax was for use in the manufacture of paper containers, 20 percent was for paper wrappers, 13 percent was used for candles and novelty decorator items, 10 percent was for corrugated paperboard, and other uses accounted for the balance. Two projects are underway that will, if successful, create an additional demand for petroleum wax. One is the use of hot melts for carpet backing, and the other is for coating paper for use as an agricultural mulch to accelerate plant growth.

Coke.—The strong export market for petroleum coke continued in 1968, with exports increasing 20 percent to 3,899,000 short tons. Refineries used 10,845,000 tons for fuel in 1968, including 9,165,000 tons that was burned off the catalytic cracking units. Other uses, which include petroleum coke with low sulfur content for use in the manufacture of electrodes required in the electrolytic production of aluminum, declined about 3 percent.

Still Gas.—Refiners used 149,796,000 barrels (921,850 million cubic feet) of still gas as fuel in 1968, and 9,844,000 barrels was used as petrochemical feedstocks.

Petrochemical Feedstocks.—The petrochemical industry used 92,935,000 barrels of base feedstocks from the petroleum industry in 1968, compared with 83,935,000 barrels in 1967. Exports of petrochemical feedstocks declined slightly.

Miscellaneous Finished Products.—Included in this category are a wide assortment of miscellaneous products of refineries and natural gas processing plants, including absorption oils, insulating oils, insecticides, medicinal oils, petrochemicals, and solvents. These products may be sold directly to consumers or in bulk to specialty companies which package and distribute them under various trade names. The demand for miscellaneous oils was 17,842,000 barrels in 1968. This was a gain of almost 12 percent, and offset the 6-percent decline in 1967.

Unfinished Oils.—Unfinished oils include all oils that will be cracked or further distilled at refineries. The rerun (net) of unfinished oils represents imports plus or minus the change in stocks.

Imports of unfinished oils are included with crude oil under the quota established by the Oil Import Administration. By regulation, imports of unfinished oils are restricted to 15 percent of the crude oil and unfinished oils quota in District I–IV and 25 percent in District V.

TRANSPORTATION AND DISTRIBUTION

CRUDE OIL

A transportation system consisting of pipelines, tankers, barges, tank cars, and tank trucks moves the crude petroleum to refineries for processing. Refineries received 75.8 percent of their crude oil supply by pipeline, 23.0 percent by water, and 1.2 percent by tank cars and tank trucks in 1968.

The largest domestic market for petroleum is the group of eastern seaboard States (PAD district I), while the second largest market is in the midwest area (PAD district II). Most of the domestic supply of crude oil, as well as refined products, is obtained from PAD district III. Shipments of crude oil and refined products to other PAD districts from district III in 1968 amounted to 4.9 million barrels a day with district I receiving 3.1 million barrels, or 62 percent of the total. District II received an average of 1.7 million barrels a day, or 35 percent of the total shipped from District III.

Data collected on receipts of domestic and foreign crude petroleum at refineries in the United States show receipts from local production (intrastate), receipts from other States (interstate), and receipts of imported crude. These data indicate the final receipts by water, pipelines, and tank car and truck. Receipts of domestic crude by water usually are moved by pipeline from the point of production to the point of water shipment.

The total receipts of crude oil at refineries in 1968 were 3,782.1 million barrels, an increase of 190.0 million barrels. Receipts from domestic sources increased 129.7 million barrels in 1968, overland receipts of foreign crude oil were 22.6 million barrels higher, and foreign receipts from overseas sources increased 37.7 million barrels.

During 1968, refineries processed 3,774.4 million barrels of crude oil, reported a net of 1.1 million barrels used for refinery fuel and losses, and added 6.6 million barrels to inventories.

District I produces only 2 percent of the crude oil refined in that area, and uses 55 percent foreign crude oil; District III supplies 93 percent of the remaining 204 million barrels of domestic crude oil requirements. This crude oil from District III is moved by tankers and barges from the gulf coast to the east coast and comprises the major portion of waterborne domestic crude-oil shipments between PAD districts. Some crude oil is shipped from District III to District II via the Mississippi River, but the quantity is small and will continue to decline now that the new Capline Pipeline from Louisiana to Illinois is in operation. In addition, a large volume of crude oil is moved to refining centers by tanker and barges within District III and District V.

District I received 263.9 million barrels, or 56 percent of the foreign crude oil imported into the United States in 1968, and 242.6 million barrels was from overseas origins; the balance was shipped by pipeline from Canada to refineries in the Buffalo, N.Y. area.

A further decline in crude oil production in District II and an increasing demand made it necessary to bring in an additional 44.2 million barrels of crude oil from PAD districts III and IV and 22.1 million barrels more from Canada in 1968. Refineries within the district received 445.1 million barrels of crude from production within the district, 450.8 million barrels from PAD district III, 109.3 million barrels from PAD district IV, and 78.5 million barrels from Canada.

PAD districts III and IV are surplus crude oil areas and receive only token amounts of oil from other districts or from foreign sources.

Because of the increased crude oil production in Alaska and California in 1968, PAD district V was less dependent on other sources of crude oil. Imports from Canada declined 3.8 million barrels, overseas imports were down 7.8 million barrels, and receipts from PAD district III and IV declined 3.1 million barrels.

PIPELINES

As of January 1, 1968, there were 209,478 miles of pipelines transporting crude oil and refined products in the United States. This represents a 1,389-mile decline from the total reported in the previous Bureau of Mines survey for January 1, 1965. Mileage of crude-oil gathering lines declined 2,917 miles during the 3-year period and crude oil trunklines declined 1,558 miles. The January 1, 1968, survey did not include data for Capline, which started operating approximately 630 miles of 40-inch crude trunk lines from Louisiana to Patoka, Ill., in the summer of 1968, nor did it include off-takes from that line to Northern Illinois and Kentucky which would be at least an additional 340 miles. The decline in crude-oil gathering lines between 1965 and 1968 reflects the impact of the 15,000 fewer crude-oil producing wells in operation as of December 31, 1967. Larger capacity trunk lines are replacing smaller lines. The total mileage of refined product pipelines increased 3,086 miles between January 1, 1965, and January 1, 1968. The total crude oil required for pipeline fill in 1968 was 66.9 million barrels, compared with 64.9 million barrels in 1965. The refined product pipelines required 37.7

million barrels for fill in 1968, compared with 35.8 million in 1965.

RAIL, TANK TRUCK, AND BARGES

In a survey conducted by the National Petroleum Council in 1967, it was reported there were 142,356 U.S.-based tank cars having a total capacity of 1.7 billion gallons suitable for carrying petroleum and petroleum products as of June 1, 1967.

The Council's survey of tank trucks and trailer units estimated that as of January 1, 1967, there were 81,300 units in service with an aggregate capacity of 497 million gallons.

There were 2,925 non-propelled and self-propelled barges and small lake tankers suitable for transporting petroleum and petroleum products in bulk on inland waterways, the Great Lakes, and in some instances, salt water as of January 1, 1967. About 76 percent of this fleet was operating on the Mississippi River and the Gulf Intracoastal Canal. The combined capacity for this fleet was 35.5 million barrels.

REFINED PRODUCT DISTRIBUTION

PAD district I received 947 million barrels of refined products from the other districts in 1968 and PAD district III supplied 927 million barrels of this total. For the first time, the volume shipped by pipeline from District III (488 million barrels) exceeded that shipped by coastal vessels. Pipelines from District II supplied 18 million barrels of refined product demand in District I, but in turn, pipelines from District I shipped almost 39 million barrels of refined product into District II.

District V refineries were able to supply a larger portion of the demand requirements within the district in 1968 so that shipments from District III and IV declined 5 million barrels.

STOCKS

The total stocks of all oils at the end of 1968 was 999.6 million barrels, an increase of 55.5 million barrels for the year. Crude oil stocks increased 23.2 million barrels, stocks of distillate fuel oils increased 13.4 million barrels, and stocks of liquefied gases were 12.0 million barrels higher. At the end of September, stocks exceeded the 1 billion mark for the first time and totaled 1,032 million barrels. Warmer than normal weather during October and November slowed the usual drawdown of fuel oil stocks, but an exceptionally cold December helped to reduce closing stocks to just below the billion-barrel level.

PRICES

Crude Oil.—On January 1, 1968, four companies in the gulf coast area raised the posted prices for crude oil from certain fields in Texas, Louisiana, and Mississippi an average of 5 to 7 cents per barrel. Other companies followed suit and the trend spread to the mid-continent States and then into the Rocky Mountain area. By July 31, the higher posted prices applied to most crude oil produced in these areas. The overall effect on the average wellhead value of crude oil in the United States was a 2-cent-per-barrel increase for the year to $2.94.

Refined Products.—The increased cost of crude oil resulted in slightly higher prices for gasoline, kerosine, and distillate fuel oil at the refineries. The yearly average price of gasoline at refineries in Oklahoma increased 0.025 cent per gallon, and distillate fuel oil and kerosine prices increased 0.008 cent per gallon. The price of regular-grade gasoline to the consumer, as reported for 55 representative cities by Platts' Oilgram Price Service, increased 0.055 cent per gallon to 33.71 cents as a result of higher margins to dealers and an increase in State and local taxes. There was no increase in the Federal tax of 4 cents per gallon, but the average State and local taxes were 0.17 cent higher for the year. Refinery prices for residual fuel oils were fairly steady, but there was a softening of prices for Bunker "C" oil for ships' bunkers in the east and west coast markets. Excess supplies of propane resulted in producers' reducing the net contract price by 1.3 cents per gallon at New York Harbor, 1.5 cents per gallon in New Orleans, and 1.7 cents per gallon in the Oklahoma area.

According to the Bureau of Labor Statistics, the average annual retail price of No. 2 distillate fuel oil in 1968 was 17.4 cents per gallon compared with 16.9 cents in 1967.

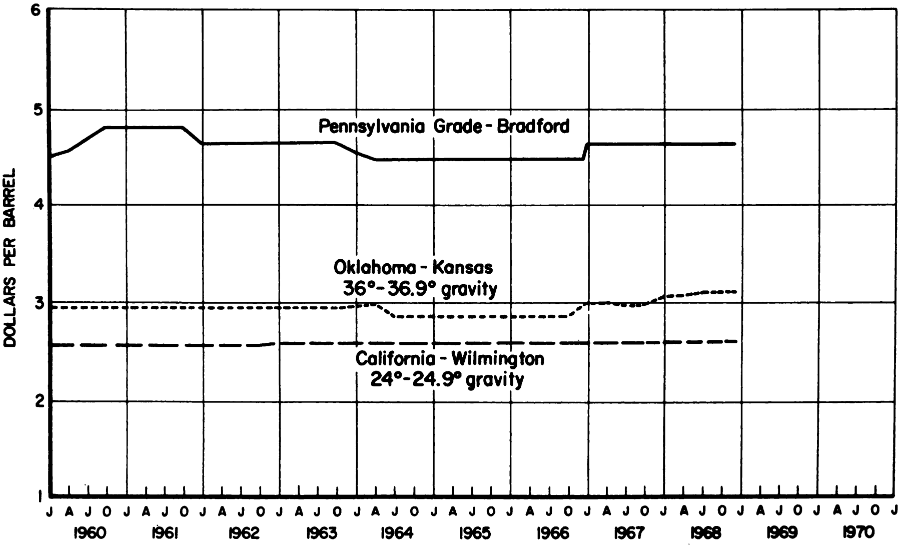

Figure 6.—Posted prices of selected grades of crude petroleum in the United States, by quarters.

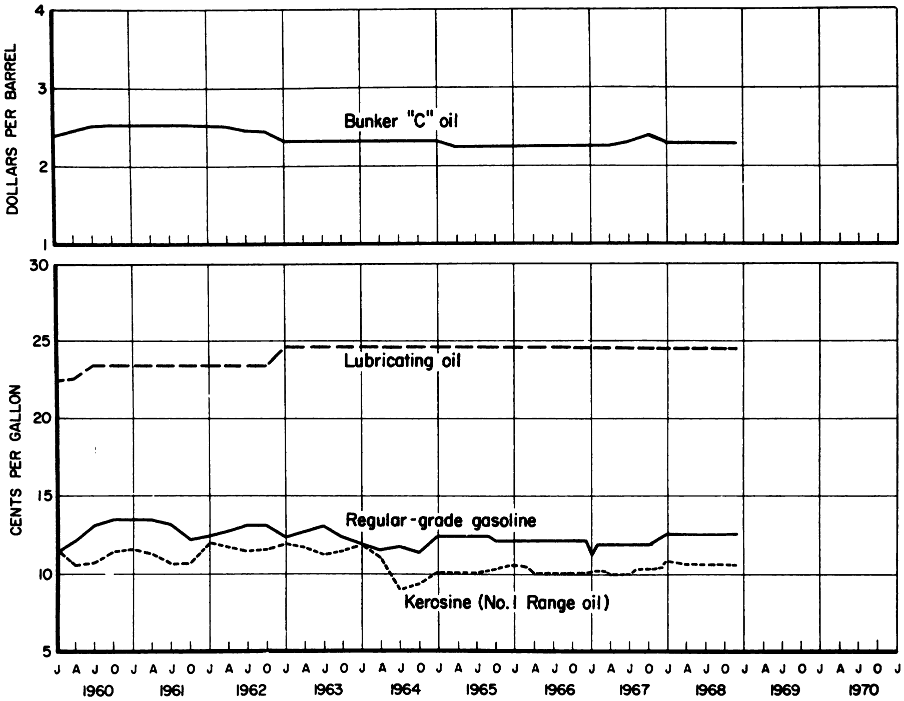

Figure 7.—Prices of Bunker "C" oil at New York Harbor, bright stock at Oklahoma refineries, No. 1 range oil at Chicago district, and regular-grade gasoline at refineries in Oklahoma, by quarters.

FOREIGN TRADE

Foreign trade statistics reported in this section were compiled from two sources. The imports of crude and unfinished oils were obtained from the petroleum-refining companies. Imports of refined petroleum products and exports were compiled by the Bureau of the Census.

Total imports of crude oil and refined products in 1968 were 1,038.4 million barrels, compared with 926.0 million in 1967. The higher than normal growth in imports in 1968 was the result of the Oil Import Administration extending the expiration date of the 1967 quotas which importers had been unable to use. Imports lagged behind the 1967 level for the first half of 1968 as importers waited for tanker rates to return to nearer the pre-Suez level of June 1967. Rates did not decline, but some of the extended quotas were good only through July 31, 1968. To avoid the loss of the carryover quotas, plus the 1968 quotas, a high level of imports was scheduled from mid-June through the balance of the year.

Crude oil imports for the year increased 60.7 million barrels to 472.3 million, and imports of refined product imports increased 51.7 million barrels to 566.1 million. Refined products imported into the east coast area in 1968 comprised 511.5 million barrels, 53.9 million barrels above the 1967 level, with increased imports of distillate fuel oil and residual fuel oil accounting for 39.8 million barrels of the increase; gasoline, 11.0 million barrels; and bonded jet fuels, 2.9 million barrels. Residual fuel oil and No. 4 distillate fuel oil can be imported by license into the east coast and are not restricted by quotas; jet fuels imported in bond for fueling aircraft for overseas destinations are also excluded from oil import regulations. The large increase in gasoline imports into the east coast was due primarily to additional shipments from Puerto Rico which were authorized by the Secretary of the Interior.

Efforts were made during 1968 to amend the section of the oil import regulation restricting the importation of foreign crude and unfinished oils into foreign trade zones. Companies proposing the change planned to build refineries in these zones and would request quotas only for those refined products entering the States for consumption that are restricted by the oil import regulations. This would permit a free flow of bonded fuels such as jet fuels, residual fuel oils, and distillate fuel oils. No. 4 distillate and residual fuel oils could be shipped into the east coast States to meet all of the operating company's sales and contractual commitments. Import duties would be paid only on the products entering the States for consumption. Hearings were held on these proposals but decisions are still pending.

As was expected, exports returned to the normal level of 85.2 million barrels in 1968. This was a decline of 26.9 million from the 1967 high created by the Suez crisis. Residual fuel oil, petroleum coke, and lubricating oils comprise the bulk of the export market for petroleum (69 percent in 1968), but only petroleum coke has shown any substantial growth.

NATIVE ASPHALT

Bituminous Limestone, Sandstone, and Gilsonite.—To avoid disclosure of individual company data, a combined production and value are reported for these commodities. Production in 1968 was 1,786,840 short tons, 79,826 tons below that of 1967. The limestone was produced in Alabama and Texas; the sandstone in Kentucky and Missouri; and the gilsonite in Utah. The value of the production in 1968 was $8,127,000.

Table 2.—Supply and demand of all oils in the United States, by months

(Thousand barrels)

	1967												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
New supply:													
Domestic production:													
Crude petroleum	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
Natural gas liquids	43,457	39,309	43,147	42,544	43,259	41,455	42,655	43,249	41,556	44,673	44,015	45,137	514,456
Benzol, etc., used at refineries	8	7	7	6	7	7	11	6	6	7	8	7	87
Imports:[1]													
Crude petroleum	41,107	29,220	37,585	38,219	39,880	33,640	30,092	31,458	31,458	31,890	29,622	37,478	411,649
Refined products	55,333	46,640	52,008	46,353	40,450	37,012	31,948	35,349	32,736	46,546	40,588	49,384	514,342
Total new supply	405,482	356,542	397,601	381,374	383,519	368,288	388,477	402,557	378,601	402,113	383,581	408,141	4,656,276
Increase (+) or decrease (−) in stocks	+644	−20,545	−14,443	+33,595	+12,953	+5,883	+20,779	+20,626	+24,301	+12,041	−24,026	−8,802	+63,006
Demand:													
Total demand	404,838	377,087	412,044	347,779	370,566	362,405	367,698	381,931	354,300	390,072	407,607	416,943	4,593,270
Exports:[2]													
Crude petroleum	27	-------	87	251	-------	1,830	8,526	8,188	6,033	1,421	124	54	26,541
Refined products	5,825	6,599	6,893	6,927	6,764	6,743	7,714	8,244	8,382	7,603	8,489	5,836	85,519
Domestic demand:													
Gasoline:													
Motor gasoline	184,710	126,276	148,941	143,166	157,901	162,528	160,005	168,059	150,020	157,649	151,994	148,533	1,809,782
Aviation gasoline	2,474	2,679	3,185	2,450	3,409	3,155	2,573	2,930	2,581	2,828	2,445	2,195	32,904
Total	187,184	128,955	152,126	145,616	161,310	165,683	162,578	170,989	152,601	160,477	154,439	150,728	1,842,686
Special naphthas	1,988	2,032	2,342	2,061	2,237	2,150	1,877	2,265	2,019	2,336	2,156	1,740	25,203
Kerosine	13,574	12,397	9,573	5,702	6,171	4,274	5,461	6,101	7,141	7,704	10,544	11,436	100,078
Distillate fuel oil	93,222	90,361	91,250	58,436	60,350	48,831	47,814	46,064	47,312	60,348	80,803	93,359	818,150
Residual fuel oil	70,602	63,766	68,238	52,317	49,376	45,066	42,496	43,700	40,296	55,647	57,228	63,153	651,885
Jet fuel:													
Naphtha type	7,752	7,224	8,820	9,568	8,695	9,483	10,042	9,729	11,040	9,975	10,356	8,862	111,546
Kerosine type	13,554	13,041	15,026	14,758	15,936	16,075	17,150	16,508	14,915	18,451	15,989	17,821	189,224
Total	21,306	20,265	23,846	24,326	24,631	25,558	27,192	26,237	25,955	28,426	26,345	26,683	300,770
Lubricants	3,744	2,955	3,847	3,552	3,814	4,196	3,560	4,015	3,896	3,471	3,629	3,444	44,123
Wax	317	291	328	341	310	323	292	343	345	346	366	266	3,868
Coke	6,706	5,227	7,161	5,711	6,377	5,886	6,220	6,650	6,059	6,188	6,286	6,659	75,130
Asphalt	4,699	3,107	5,951	7,789	11,899	15,518	16,340	20,327	16,725	15,035	9,335	4,400	131,125
Road oil	101	168	170	178	636	968	1,381	1,465	833	704	335	154	7,093
Still gas	11,241	10,004	10,941	10,551	12,485	12,646	12,550	12,547	12,192	12,249	11,307	11,321	140,034
Liquefied gases (including ethane):													
LRG [3] for fuel use	5,796	5,172	5,759	5,192	5,414	5,507	5,695	5,544	5,484	4,901	5,581	5,983	65,978

LRG [3] for chemical use	3,887	3,268	3,972	4,084	3,717	3,796	3,477	3,242	3,648	3,378	3,480	4,006	43,950
LPG [4] for fuel and chemical use	25,816	22,491	20,253	14,803	15,173	14,293	15,066	16,188	16,665	20,860	26,259	26,656	234,523
Total	35,499	30,926	29,984	24,079	24,304	23,596	24,238	24,974	25,797	29,139	35,270	36,645	344,451
Petrochemical feedstocks:[5]													
Still gas	896	690	836	705	659	643	751	843	819	981	868	891	9,532
Naphtha −400°	4,135	3,592	4,469	3,762	3,842	4,261	3,758	4,033	3,830	5,011	4,754	4,902	50,349
Other	1,960	1,923	1,974	1,941	2,097	1,769	2,124	1,957	2,486	1,894	1,933	1,996	24,054
Total	6,991	6,205	7,279	6,408	6,598	6,673	6,633	6,833	7,135	7,886	7,555	7,789	83,935
Miscellaneous products	1,590	1,252	1,341	1,237	1,514	1,285	1,266	1,233	1,217	1,305	1,535	1,220	15,995
Total domestic product demand	408,764	377,911	414,377	348,304	372,012	362,653	359,898	373,743	349,523	391,211	407,133	418,997	4,584,526
Crude losses	311	179	247	298	326	278	251	305	211	282	300	288	3,276
Less net processing gain	10,089	7,602	9,060	8,001	8,536	9,099	8,691	8,549	9,849	10,445	8,439	8,232	106,592
Total domestic demand	398,986	370,488	405,564	340,601	363,802	353,832	351,458	365,499	339,885	381,048	398,994	411,053	4,481,210
Stocks:													
Crude petroleum	250,646	252,388	258,106	266,755	268,845	261,615	256,242	261,566	257,286	255,114	254,185	248,970	248,970
Unfinished oils, natural gasoline [6]	94,492	95,926	100,438	103,439	107,026	102,361	103,304	101,923	97,076	100,039	99,099	95,983	95,983
Finished products	536,611	512,890	488,217	510,162	517,438	535,216	560,425	577,108	610,536	621,786	599,629	599,158	599,158
Total	881,749	861,204	846,761	880,356	893,309	899,192	919,971	940,597	964,898	976,939	952,913	944,111	944,111
						1968							
New supply:													
Domestic production:													
Crude petroleum	279,855	270,417	288,891	273,687	285,356	274,319	283,846	283,150	267,972	276,402	269,076	276,071	3,329,042
Natural gas liquids	45,204	43,509	47,104	45,229	47,005	44,497	46,110	45,709	44,570	46,655	46,459	48,260	550,311
Other hydrocarbons and hydrogen refinery input	86	221	286	313	270	269	326	350	380	265	304	307	3,377
Imports:[1]													
Crude petroleum	30,537	28,152	35,506	32,459	37,462	40,212	45,717	43,243	42,474	45,912	40,779	49,870	472,323
Refined products	62,910	54,155	58,481	43,722	38,133	42,885	44,687	37,452	43,127	45,053	43,094	52,375	566,074
Total new supply	418,592	396,454	430,268	395,410	408,226	402,182	420,686	409,904	398,523	414,287	399,712	426,883	4,921,127
Increase (+) or decrease (−) in stocks	−53,563	−26,888	+18,073	+16,879	+31,613	+29,710	+31,060	+19,552	+21,914	+9,085	−5,837	−36,137	+55,461
Unaccounted for crude petroleum [7]	−553	−218	+760	−403	+2,032	−520	+216	+3,506	−834	+1,609	+1,296	+247	+7,138
Demand:													
Total demand	471,602	423,124	412,955	378,128	378,645	371,952	389,842	393,858	375,775	406,811	406,845	463,267	4,872,804
Exports:[2]													
Crude petroleum	250	283	41	144	87	226	2	86	76	111	402	94	1,802
Refined products	5,636	6,384	7,697	6,860	7,771	7,495	7,002	6,846	7,375	6,490	6,609	7,214	83,379

See footnotes at end of table.

Table 2.—Supply and demand of all oils in the United States, by months—Continued

(Thousand barrels)

	1968 ^{p}												
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Domestic demand:													
Gasoline:													
Motor gasoline	145,474	142,529	152,923	159,744	166,123	163,737	177,553	176,658	156,988	167,662	156,396	159,582	1,925,369
Aviation gasoline	2,359	1,982	2,810	2,968	2,681	2,628	2,962	2,651	2,793	2,455	1,957	2,158	30,404
Total	147,833	144,511	155,733	162,712	168,804	166,365	180,515	179,309	159,781	170,117	158,353	161,740	1,955,773
Special naphthas	2,142	2,228	2,367	1,908	2,131	2,357	2,530	2,134	2,409	2,285	2,188	2,325	27,004
Kerosine	16,257	12,176	9,683	5,562	5,854	4,792	4,299	6,153	6,602	7,819	10,491	13,422	103,110
Distillate fuel oil	117,802	100,672	85,388	60,140	56,085	47,865	46,002	49,468	53,805	62,366	76,371	106,747	862,711
Residual fuel oil	84,403	69,143	63,873	51,452	44,484	48,154	46,007	44,073	48,308	50,899	57,631	71,446	679,873
Jet fuel:													
Naphtha type	8,907	9,327	10,582	11,351	11,364	10,730	9,368	11,073	10,540	12,960	10,103	10,247	126,552
Kerosine type	17,152	17,867	17,284	17,860	16,668	18,423	19,826	20,006	19,124	19,953	18,430	19,134	221,727
Total	26,059	27,194	27,866	29,211	28,032	29,153	29,194	31,079	29,664	32,913	28,533	29,381	348,279
Lubricants	3,768	3,792	3,859	4,293	4,443	3,693	4,308	4,059	3,997	4,388	3,752	3,898	48,250
Wax	353	352	378	346	403	339	359	361	378	409	397	285	4,360
Coke	6,692	6,143	6,426	6,435	6,027	6,196	6,503	6,644	6,273	6,796	6,044	6,140	76,319
Asphalt	3,999	4,187	5,477	9,318	13,118	16,170	19,911	19,955	17,478	17,030	8,998	5,466	141,107
Road oil	141	184	240	314	520	917	1,293	1,437	909	668	300	157	7,080
Still gas	13,297	10,486	11,488	11,529	12,735	13,132	13,993	13,629	12,851	12,490	11,696	12,470	149,796
Liquefied gases (including ethane):													
LRG [3] for fuel use	6,853	6,393	5,956	5,209	6,178	5,530	6,179	6,228	5,677	5,370	5,400	6,645	71,618
LRG [3] for chemical use	3,866	3,602	3,916	4,025	4,190	3,967	3,761	4,158	4,025	3,709	3,500	3,829	46,548
LPG [4] for fuel and chemical use	31,810	26,568	23,181	16,557	17,112	15,879	18,155	17,379	17,361	23,805	27,502	32,266	267,575
Total	42,529	36,563	33,053	25,791	27,480	25,376	28,095	27,765	27,063	32,884	36,402	42,740	385,741
Petrochemical feedstocks:[5]													
Still gas	875	786	878	792	789	774	765	846	875	864	727	873	9,844
Naphtha −400°	4,996	4,581	3,941	4,631	4,890	4,989	4,207	4,543	4,602	4,827	4,652	4,759	55,618
Other	1,920	2,072	2,377	2,052	2,656	2,008	2,605	2,905	1,764	2,563	1,957	2,594	27,473
Total	7,791	7,439	7,196	7,475	8,335	7,771	7,577	8,294	7,241	8,254	7,336	8,226	92,935
Miscellaneous products	1,571	1,574	1,681	1,943	1,699	1,449	1,535	1,455	1,101	1,323	1,190	1,321	17,842
Total domestic product demand	474,637	426,644	414,708	378,429	380,150	373,729	392,121	395,815	377,860	410,641	409,682	465,764	4,900,180
Crude losses	343	327	343	380	354	340	358	358	342	349	335	355	4,134
Less net processing gain	9,264	10,514	9,834	7,635	9,717	9,838	9,641	9,247	9,878	10,780	10,183	10,160	116,691

Total domestic demand	465,716	416,457	405,217	371,124	370,787	364,231	382,838	386,926	368,324	400,210	399,834	455,959	4,787,623
Stocks:													
Crude petroleum	244,946	245,271	256,864	262,087	262,021	264,896	265,755	266,368	262,771	266,330	271,587	272,193	272,193
Unfinished oils, natural gasoline [6]	93,598	94,273	96,247	100,695	106,792	104,233	104,205	102,703	98,450	101,523	99,899	98,865	98,865
Finished products	552,004	524,116	528,622	535,830	561,412	590,806	621,035	641,476	671,240	673,693	664,223	628,514	628,514
Total	890,548	863,660	881,733	898,612	930,225	959,935	990,995	1,010,547	1,032,461	1,041,546	1,035,709	999,572	999,572

---

[p] Preliminary.

[1] Bureau of Mines data for crude oil and unfinished oils, U.S. Department of Commerce data for all other imports.

[2] U.S. Department of Commerce data.

[3] Liquefied refinery gas.

[4] Liquefied petroleum gas.

[5] Produced at petroleum refineries. Data for LRG for petrochemical feedstocks are included with those for "Liquefied gases."

[6] Includes plant condensate and isopentane.

[7] Represents the difference between supply and indicated demand for crude petroleum beginning with 1968.

Table 3.—Estimates of proved crude-oil reserves in the United States on December 31, by States[1]

(Million barrels)

State	1964	1965	1966	1967	1968
Eastern States:					
Illinois	391	371	362	336	314
Indiana	61	57	48	47	40
Kentucky	118	108	101	94	80
Michigan	58	53	71	63	55
New York	14	12	10	15	18
Ohio	100	101	101	114	132
Pennsylvania	87	77	73	63	59
West Virginia	59	55	57	56	54
Total	888	834	823	788	747
Central and Southern States:					
Alabama	50	66	85	79	73
Arkansas	205	201	181	176	159
Kansas	797	752	726	625	601
Louisiana [2]	5,162	5,246	5,408	5,456	5,608
Mississippi	357	360	374	357	326
Nebraska	71	71	57	63	55
New Mexico	957	895	1,025	926	865
North Dakota	377	395	321	290	287
Oklahoma	1,586	1,517	1,518	1,459	1,395
Texas [2]	14,300	14,303	14,077	14,494	13,810
Total	23,862	23,806	23,772	23,925	23,179
Mountain States:					
Colorado	346	327	344	340	420
Montana	252	274	282	308	345
Utah	219	197	213	201	180
Wyoming	1,204	1,169	1,073	1,044	1,101
Total	2,021	1,967	1,912	1,893	2,046
Pacific Coast States:					
Alaska	83	160	322	381	[3] 373
California [2]	4,125	4,567	4,608	4,369	4,341
Total [1]	4,208	4,727	4,930	4,750	4,714
Other States [4]	12	18	15	21	21
Total United States	30,991	31,352	31,452	31,377	30,707

---

[1] From reports of Committee of Petroleum Reserves, American Petroleum Institute. Includes crude oil that may be extracted by present methods from fields completely developed or sufficiently explored to permit reasonably accurate calculations. The change in reserves during any year represents total new discoveries, extensions, and revisions, minus production.

[2] Includes offshore reserves; the Dec. 31, 1968 total for Louisiana and Texas was 2,539.

[3] Does not give credit to reserves associated with 1968 discoveries on the north slope of Alaska. As of Dec. 31, 1968, the API Committee did not have sufficient information to make a meaningful determination of proved reserves associated with these discoveries.

[4] Includes Arizona, Florida, Missouri, Nevada, South Dakota, Tennessee, and Virginia.

Table 4.—Supply and disposition of crude petroleum (including lease condensate) in the United States

(Thousand barrels)

Supply and disposition	1964	1965	1966	1967	1968 p
Supply:					
Production	2,786,822	2,848,514	3,027,763	3,215,742	3,329,042
Imports [1]	438,643	452,040	447,120	411,649	472,323
Total new supply	3,225,465	3,300,554	3,474,883	3,627,391	3,801,365
Stock changes:					
Domestic crude	−8,308	−8,404	+17,863	+7,799	+17,653
Foreign crude	+1,004	−1,364	+239	+2,780	+5,570
Unaccounted for [2]	---------	---------	---------	---------	+7,138
Disposition by use:					
Runs of domestic crude	2,785,895	2,847,821	3,000,789	3,174,004	3,308,044
Runs of foreign crude	437,434	453,021	446,404	408,590	466,316
Exports [3]	1,363	1,097	1,477	26,541	1,802
Transfers:					
Distillate	755	773	752	730	712
Residual	3,720	3,950	3,551	3,671	4,272
Losses	3,602	3,660	3,808	3,276	4,134
Total disposition by use	3,232,769	3,310,322	3,456,781	3,616,812	3,785,280

p Preliminary.

[1] Bureau of Mines data.

[2] Represents the difference between supply and indicated demand for crude petroleum beginning with 1968.

[3] U.S. Department of Commerce data.

Table 5.—Supply and disposition of crude petroleum (including lease condensate) in the United States

(Thousand barrels)

Supply and disposition	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1967													
Supply:													
Production	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
Imports [1]	41,107	29,220	37,585	38,219	39,880	33,640	30,092	31,458	31,458	31,890	29,622	37,478	411,649
Total new supply	306,684	270,586	302,439	292,471	299,803	289,814	313,868	323,953	304,303	310,887	298,970	313,613	3,627,391
Change in stocks, end of period:													
Domestic crude	+9,801	+1,745	+3,484	+7,282	−537	−4,202	−1,278	+6,318	−5,778	−1,919	+811	−7,928	+7,799
Foreign crude	+2,454	−3	+2,234	+1,367	+2,627	−3,028	−4,095	−994	+1,498	−253	−1,740	+2,713	+2,780
Disposition by use:													
Runs of domestic crude	255,130	239,192	260,742	246,025	259,873	257,899	275,874	277,278	272,054	278,822	267,711	283,404	3,174,004
Runs of foreign crude	38,642	29,185	35,319	36,840	37,220	36,682	34,154	32,465	29,903	32,114	31,369	34,697	408,590
Exports [2]	27	-------	87	251	-------	1,830	8,526	8,188	6,033	1,421	124	54	26,541
Transfers:													
Distillate	63	57	66	58	61	60	63	64	60	61	60	57	730
Residual	256	231	260	350	233	295	373	329	322	359	335	328	3,671
Losses	311	179	247	298	326	278	251	305	211	282	300	288	3,276
Total disposition by use	294,429	268,844	296,721	283,822	297,713	297,044	319,241	318,629	308,583	313,059	299,899	318,828	3,616,812
1968 p													
Supply:													
Production	279,855	270,417	288,891	273,687	285,356	274,319	283,846	283,150	267,972	276,402	269,076	276,071	3,329,042
Imports [1]	30,537	28,152	35,506	32,459	37,462	40,212	45,717	43,243	42,474	45,912	40,779	49,870	472,323
Total new supply	310,392	298,569	324,397	306,146	322,818	314,531	329,563	326,393	310,446	322,314	309,855	325,941	3,801,365
Change in stocks, end of period:													
Domestic crude	−1,277	+1,101	+9,324	+4,306	−844	+2,825	−782	+762	−1,780	+5	+7,863	−3,850	+17,653
Foreign crude	−2,747	−776	+2,269	+917	+778	+50	+1,641	−149	−1,817	+3,554	−2,606	+4,456	+5,570
Unaccounted for [3]	−553	−218	+760	−403	+2,032	−520	+216	+3,506	−834	+1,609	+1,296	+247	+7,138
Disposition by use:													
Runs of domestic crude	279,642	268,151	279,536	268,027	287,427	270,038	284,115	285,153	268,029	277,183	261,387	279,356	3,308,044
Runs of foreign crude	33,230	28,879	33,235	31,482	36,653	40,131	44,011	43,307	44,342	42,304	43,374	45,368	466,316
Exports [2]	250	283	41	144	87	226	2	86	76	111	402	94	1,802
Transfers:													
Distillate	58	57	65	61	54	58	61	62	60	62	55	59	712
Residual	340	329	344	476	341	343	373	320	360	355	341	350	4,272
Losses	343	327	343	330	354	340	358	358	342	349	335	355	4,134
Total disposition by use	313,863	298,026	313,564	300,520	324,916	311,136	328,920	329,286	313,209	320,364	305,894	325,582	3,785,280

p Preliminary except for crude petroleum production.

[1] Bureau of Mines data.

[2] U.S. Department of Commerce.

[3] Represents the difference between supply and indicated demand for crude petroleum starting with 1968.

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by States and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1967													
Alabama	646	569	626	615	614	593	611	613	610	609	607	635	7,348
Alaska	1,645	1,538	1,606	1,568	1,890	2,076	2,230	2,381	2,743	3,448	4,016	3,985	29,126
Arizona	12	23	72	172	282	288	324	424	366	334	321	306	2,924
Arkansas	1,902	1,712	1,865	1,770	1,813	1,718	1,757	1,754	1,690	1,744	1,651	1,699	21,075
California:													
South	11,391	10,419	11,647	11,420	11,821	11,630	12,061	12,378	12,232	12,903	12,593	13,400	143,895
Central Coastal	5,886	5,309	5,989	5,792	5,971	5,772	6,064	5,923	5,735	5,927	5,738	5,766	69,872
East Central	12,221	11,063	12,289	11,976	12,442	11,903	12,229	12,186	11,797	12,405	11,920	12,349	144,780
North	50	49	48	49	61	56	58	61	57	59	64	60	672
Total California	29,548	26,840	29,973	29,237	30,295	29,361	30,412	30,548	29,821	31,294	30,315	31,575	359,219
Colorado	2,866	2,621	2,903	2,849	2,975	2,814	2,915	2,915	2,778	2,941	2,415	2,913	33,905
Florida	146	129	142	137	137	135	137	130	123	126	116	110	1,568
Illinois	5,287	4,429	5,222	4,935	5,188	4,957	4,883	5,014	4,786	4,964	4,808	4,669	59,142
Indiana	929	798	879	853	868	831	864	843	796	835	806	779	10,081
Kansas	8,595	7,782	8,675	8,137	8,557	8,218	8,283	8,463	8,061	8,288	8,082	8,059	99,200
Kentucky	1,401	1,198	1,358	1,267	1,352	1,290	1,281	1,311	1,247	1,317	1,277	1,236	15,535
Louisiana:													
Gulf Coast	57,513	53,029	57,184	55,058	55,954	56,707	66,102	68,263	61,277	62,828	61,821	63,754	719,490
Rest of State	4,916	4,364	4,575	4,600	4,672	4,505	4,406	4,822	4,620	4,617	4,458	4,482	55,037
Total Louisiana	62,429	57,393	61,759	59,658	60,626	61,212	70,508	73,085	65,897	67,445	66,279	68,236	774,527
Michigan	1,154	1,076	1,184	1,115	1,182	1,120	1,140	1,179	1,120	1,154	1,119	1,121	13,664
Mississippi	4,660	4,295	4,816	4,631	4,762	4,675	4,916	4,920	4,803	4,968	4,813	4,888	57,147
Missouri	6	6	6	6	7	6	7	7	6	6	6	6	75
Montana	2,823	2,603	2,844	2,693	2,783	2,751	2,858	2,916	2,941	3,066	3,212	3,469	34,959
Nebraska	1,114	1,003	1,109	1,091	1,141	1,083	1,133	1,140	1,120	1,166	1,125	1,148	13,373
Nevada	27	18	25	23	26	24	22	20	12	30	24	28	279
New Mexico:													
Southeastern	9,884	9,068	9,863	9,366	9,580	9,148	9,398	9,842	9,775	9,927	9,551	9,656	115,058
Northwestern	1,029	924	1,003	992	960	891	876	881	841	869	896	924	11,086
Total New Mexico	10,913	9,992	10,866	10,358	10,540	10,039	10,274	10,723	10,616	10,796	10,447	10,580	126,144
New York	155	146	175	167	182	172	176	172	161	162	150	154	1,972
North Dakota	2,235	2,000	2,239	2,146	1,673	1,952	2,201	2,158	2,147	2,229	2,138	2,197	25,315
Ohio	843	723	857	797	829	807	792	903	833	870	823	847	9,924
Oklahoma	20,038	18,267	20,115	18,988	19,385	18,596	19,508	19,604	18,902	19,468	18,835	19,043	230,749
Pennsylvania	372	327	375	365	399	397	373	395	360	378	329	317	4,387
South Dakota	20	21	18	17	15	16	18	18	16	18	17	17	211
Tennessee	1	-------	1	-------	1	-------	1	1	1	-------	1	-------	7

See footnotes at end of table.

Table 6.—Production of crude petroleum (including lease condensate) in the United States, by States and months—Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Texas:													
Gulf Coast	17,225	15,357	16,812	16,036	16,241	16,233	20,266	21,522	19,014	18,901	17,726	20,483	215,816
West Texas	43,323	38,910	42,405	40,568	41,121	40,658	46,904	49,223	45,305	45,513	43,155	43,909	520,994
East Texas Field	4,404	3,899	4,045	3,835	3,864	3,922	4,992	5,401	4,657	4,446	4,147	4,303	51,915
Panhandle	2,996	2,674	2,977	2,849	2,890	2,797	2,949	2,998	2,870	2,944	2,823	2,940	34,707
Rest of State	25,158	22,532	24,652	23,462	24,035	23,646	27,104	28,056	24,847	25,766	24,467	22,805	296,530
Total Texas	93,106	83,372	90,891	86,750	88,151	87,256	102,215	107,200	96,693	97,570	92,318	94,440	1,119,962
Utah	2,046	1,910	2,104	2,056	2,097	2,062	1,775	2,043	1,983	2,048	1,989	1,935	24,048
Virginia	-------	-------	-------	1	-------	1	-------	-------	-------	-------	-------	1	3
West Virginia	347	293	306	303	227	362	296	312	265	316	254	280	3,561
Wyoming	10,311	10,282	11,843	11,547	11,926	11,362	11,866	11,303	11,948	11,407	11,055	11,462	136,312
Total:													
1967	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
1966	249,459	230,733	257,107	248,155	258,677	250,391	255,121	255,812	247,632	258,008	252,825	263,843	3,027,763
Daily average, 1967	8,567	8,620	8,544	8,475	8,385	8,539	9,154	9,435	9,095	9,000	8,978	8,908	8,810
Pennsylvania grade included in United States total	1,075	938	1,061	1,032	1,006	1,137	1,054	1,095	989	1,058	908	942	12,295
1968													
Alabama	636	590	628	636	635	616	627	632	638	670	654	673	7,635
Alaska	4,612	4,459	5,351	5,254	5,775	5,910	6,051	6,008	5,434	5,650	5,736	5,964	66,204
Arizona	368	340	326	304	293	252	257	258	254	253	236	229	3,370
Arkansas	1,765	1,603	1,715	1,654	1,700	1,615	1,600	1,593	1,530	1,602	1,522	1,565	19,464
California:													
South	13,659	12,868	13,948	13,313	14,154	13,675	14,044	14,069	13,638	14,173	13,839	14,395	165,775
Central Coastal	5,444	5,149	5,472	5,184	5,352	5,208	5,401	5,498	5,329	5,555	5,297	5,357	64,246
East Central	12,348	11,724	12,462	11,963	12,319	11,880	12,226	12,238	11,693	12,101	11,706	11,966	144,626
North	64	62	65	68	71	71	65	68	70	91	80	74	849
Total California	31,515	29,803	31,947	30,528	31,896	30,834	31,736	31,873	30,730	31,920	30,922	31,792	375,496
Colorado	2,747	2,677	2,840	2,747	2,688	2,628	2,710	2,659	2,532	2,585	2,471	2,653	31,937
Florida	117	109	120	119	122	121	125	124	124	136	130	127	1,474
Illinois	4,778	4,464	4,757	4,809	4,872	4,618	4,976	4,857	4,497	4,786	4,437	4,540	56,391
Indiana	725	671	764	750	750	711	739	734	708	728	702	710	8,692
Kansas	8,163	7,737	8,120	8,099	8,027	7,751	8,041	7,837	7,797	7,914	7,507	7,512	94,505
Kentucky	1,194	1,153	1,181	1,225	1,216	1,126	1,194	1,156	1,137	1,203	1,116	1,135	14,036
Louisiana:													
Gulf Coast	63,320	63,258	66,069	60,092	66,026	63,400	65,197	66,240	62,054	63,112	62,511	65,276	766,555
Rest of State	4,382	4,208	4,455	4,187	4,344	4,126	4,278	4,314	4,029	4,232	4,122	4,194	50,871
Total Louisiana	67,702	67,466	70,524	64,279	70,370	67,526	69,475	70,554	66,083	67,344	66,633	69,470	817,426
Michigan	1,132	1,040	1,104	1,110	1,111	1,048	1,117	1,085	1,044	1,126	1,037	1,020	12,974
Mississippi	4,861	4,609	4,964	4,757	4,961	4,786	4,939	4,979	4,860	5,041	4,886	5,065	58,708

Missouri	7	6	7	5	5	5	5	5	5	5	5	5	65
Montana	3,457	3,200	3,949	3,897	4,273	4,348	4,480	4,429	4,096	4,149	4,099	4,083	48,460
Nebraska	1,134	1,079	1,166	1,105	1,131	1,088	1,114	1,093	1,062	1,087	1,077	1,047	13,183
Nevada	29	25	24	22	18	19	18	16	28	24	24	24	271
New Mexico:													
Southeastern	9,834	9,263	10,034	9,678	9,988	9,528	9,942	10,005	9,764	10,237	9,862	10,034	118,169
Northwestern	969	889	930	878	880	839	823	821	788	821	850	893	10,381
Total New Mexico	10,803	10,152	10,964	10,556	10,868	10,367	10,765	10,826	10,552	11,058	10,712	10,927	128,550
New York	136	124	130	125	132	125	132	165	120	122	109	112	1,532
North Dakota	2,120	2,101	2,235	2,031	2,193	2,067	2,114	2,088	2,039	2,106	1,965	1,981	25,040
Ohio	831	858	896	959	923	904	953	1,009	964	1,036	957	914	11,204
Oklahoma	18,571	17,806	19,200	18,689	18,832	18,393	18,876	19,207	18,251	18,725	18,208	18,865	223,623
Pennsylvania	404	368	367	318	326	310	334	344	334	356	344	355	4,160
South Dakota	16	16	16	16	17	17	16	15	15	16	14	13	187
Tennessee	-------	1	-------	1	-------	1	-------	1	-------	1	-------	1	6
Texas:													
Gulf Coast	19,263	18,943	20,293	18,884	19,218	18,367	19,244	18,628	17,260	17,788	17,229	17,831	222,948
West Texas	45,728	44,162	47,040	44,671	45,873	43,571	45,240	44,654	42,231	43,663	42,255	42,478	531,566
East Texas Field	4,621	4,628	4,923	4,530	4,555	4,398	4,584	4,423	4,028	4,138	4,004	4,236	53,068
Panhandle	2,899	2,748	2,911	2,824	2,869	2,708	2,805	2,770	2,662	2,755	2,681	2,683	33,315
Rest of State	25,259	24,315	26,028	24,765	25,161	23,936	24,942	24,535	23,014	23,829	23,164	23,535	292,483
Total Texas	97,770	94,796	101,195	95,674	97,676	92,980	96,815	95,010	89,195	92,173	89,333	90,763	1,133,380
Utah	1,925	1,720	2,006	1,919	1,998	1,888	1,954	1,974	1,945	2,073	2,056	2,046	23,504
Virginia	-------	-------	-------	1	-------	-------	-------	1	-------	-------	-------	1	3
West Virginia	310	277	292	294	259	253	299	300	263	294	241	230	3,312
Wyoming	12,027	11,167	12,103	11,804	12,289	12,012	12,384	12,318	11,735	12,219	11,943	12,249	144,250
Total:													
1968	279,855	270,417	288,891	273,687	285,356	274,319	283,846	283,150	267,972	276,402	269,076	276,071	3,329,042
1967	265,577	241,366	264,854	254,252	259,923	256,174	283,776	292,495	272,845	278,997	269,348	276,135	3,215,742
Daily average, 1968	9,028	9,325	9,319	9,123	9,205	9,144	9,156	9,134	8,932	8,916	8,969	8,906	9,096
Pennsylvania grade included in United States total	1,010	934	961	922	895	863	949	1,004	903	972	878	873	11,164

Sources of 1968 data:

Alabama —Geological Survey of Alabama and State Oil and Gas Board.
Alaska —Division of Mines and Minerals, Alaska Department of Natural Resources.
Arizona —Arizona Oil and Gas Conservation Commission.
Arkansas —Arkansas Oil and Gas Commission.
California —Division of Oil and Gas, Departmet of Conservation, State of California.
Colorado —Colorado Oil and Gas Conservation Commission.
Florida —Division of Geology, Florida Board of Conservation.
Illinois —Oil and Gas Section, Illinois Geological Survey.
Indiana —Petroleum Section, Indiana Geological Survey.
Kansas —Kansas Corporation Commission.
Kentucky —Kentucky Geological Survey.
Louisiana —Louisiana Department of Conservation.
Michigan —Natural Resources Commission, Department of Natural Resources, State of Michigan.
Mississippi —Mississippi State Oil and Gas Board.
Missouri —Missouri Division of Geological Survey and Water Resources.
Montana —Oil and Gas Conservation Commission of the State of Montana.
Nebraska —Nebraska Oil and Gas Conservation Commission.
Nevada —Nevada Oil and Gas Conservation Commission.
New Mexico —New Mexico Oil Conservation Commission.
New York —Geological Survey, New York State Museum and Science Service.
North Dakota—North Dakota Geological Survey.
Ohio —Division of Oil and Gas, Department of Natural Resources, State of Ohio.
Oklahoma —Oklahoma Tax Commission.
Pennsylvania —Pennsylvania Geological Survey, Department of Internal Affairs, Commonwealth of Pennsylvania.
South Dakota —South Dakota State Geological Survey.
Tennessee —Division of Geology, Tennessee Department of Conservation.
Texas —The Railroad Commission of Texas.
Utah —Utah Oil and Gas Conservation Commission.
Virginia —Division of Mines and Quarries, Department of Labor and Industry, Commonwealth of Virginia.
West Virginia—Geological and Economic Survey, State of West Virginia.
Wyoming —Wyoming State Board of Equalization, Ad Valorem Tax Division, and the State Oil and Gas Conservation Commission.

Table 7.—Percentage of total crude petroleum produced in the United States, by States

State	1964	1965	1966	1967	1968 [p]
Texas	35.5	35.1	34.9	34.8	34.1
Louisiana	19.7	20.9	22.3	24.1	24.6
California	10.8	11.1	11.4	11.2	11.2
Oklahoma	7.3	7.1	7.4	7.2	6.7
Wyoming	5.0	4.9	4.4	4.2	4.3
New Mexico	4.1	4.1	4.1	3.9	3.8
Kansas	3.8	3.7	3.4	3.1	2.9
Alaska	.4	.4	.5	.9	2.0
Mississippi	2.0	1.9	1.8	1.8	1.7
Illinois	2.5	2.3	2.0	1.8	1.7
Montana	1.1	1.2	1.2	1.1	1.5
Colorado	1.2	1.2	1.1	1.1	1.0
North Dakota	.9	.9	.9	.8	.7
Utah	1.0	.9	.8	.7	.7
Arkansas	1.0	.9	.8	.7	.6
Kentucky	.7	.7	.6	.5	.4
Nebraska	.7	.6	.5	.4	.4
Michigan	.6	.5	.5	.4	.4
Other States	1.7	1.6	1.4	1.3	1.3
Total	100.0	100.0	100.0	100.0	100.0

[p] Preliminary.

Table 8.—Production and reserves of crude petroleum in leading fields in the United States

(Thousand barrels)

Field [1]	State	1967	1968	Total since discovery [2]	Estimated reserves
Wilmington	California	58,652	78,253	1,235,029	1,365,350
East Texas	Texas	48,460	48,460	3,808,669	1,301,331
Timbalier Bay	Louisiana	33,033	35,815	228,035	71,965
Caillou-Island	do	33,040	34,028	356,884	143,116
Midway-Sunset	California	29,258	33,201	1,024,188	184,439
Sho-Vel-Tum	Oklahoma	32,232	32,611	807,678	93,445
Wasson	Texas	28,299	30,064	502,192	147,808
Bay Marchand, Block 2	Louisiana	30,908	29,797	244,239	356,297
Seeligson (all fields)	Texas	29,015	28,938	346,202	112,376
Kelly-Snyder	do	37,075	27,636	437,060	751,240
Kern River	California	23,677	25,280	476,232	193,475
West Delta, Block 30	Louisiana	23,744	23,473	168,863	231,137
South Pass, Block 27	do	22,955	21,889	156,189	154,811
Sprayberry Trend	Texas	27,810	21,710	273,631	173,680
South Pass, Block 24	Louisiana	23,568	21,647	301,240	448,760
McArthur River	Alaska	739	21,308	22,059	170,464
Slaughter	Texas	24,471	20,256	381,692	58,308
Elk Basin	Montana, Wyoming	19,800	20,050	348,191	51,809
Huntington Beach	California	20,711	19,342	812,145	148,113
Panhandle	Texas	21,337	19,296	1,198,324	448,037
Goldsmith	do	25,915	18,568	430,685	61,432
Main Pass Block 41	Louisiana	13,111	18,272	45,509	54,491
Sooner-Trend (Dover-Hennessey)	Oklahoma	16,753	17,062	84,954	15,689
West Delta Block 27	Louisiana	7,704	15,972	38,452	47,455
Bell Creek	Montana	870	15,670	16,642	90,000
Grand Isle Block 16	Louisiana	14,212	15,592	96,060	78,940
Rangeley	Colorado	16,579	15,344	424,853	175,147
Garden Island Bay	Louisiana	13,541	15,336	92,993	27,007
Vacuum	New Mexico	14,879	15,306	175,748	109,252
Hawkins	Texas	17,637	14,964	355,309	170,642
South Timbalier Block 135	Louisiana	13,114	14,941	53,999	46,001
San Ardo	California	18,329	14,226	207,303	110,036
Middle Ground Shoal	Alaska	7,486	14,214	24,299	172,955
Grand Isle, Block 43	Louisiana	10,124	13,756	38,601	61,399
West Ranch	Texas	15,320	13,692	215,438	63,379
Swanson River	Alaska	12,985	13,620	88,571	111,424
Salt Creek	Wyoming	14,689	13,343	469,617	40,383
Granite Point	Alaska	7,001	13,119	20,172	154,880
Lake Washington	Louisiana	12,371	13,105	152,292	149,471
West Delta Block 73	do	13,249	12,910	44,739	55,261

See footnotes at end of table.

Table 8.—Production and reserves of crude petroleum in leading fields in the United States—Continued

(Thousand barrels)

Field [1]	State	1967	1968	Total since discovery [2]	Estimated reserves
Beverly Hills	California	3,401	12,780	33,425	134,952
Ward-Estes North	Texas	14,408	12,724	251,836	55,164
Lake Barre	Louisiana	16,228	12,696	132,682	117,318
Hastings, East and West	Texas	15,062	12,432	392,568	237,568
West Bay	Louisiana	12,587	12,084	124,219	85,781
Oregon Basin	Wyoming	10,628	12,031	162,589	34,411
Golden Trend	Oklahoma	12,952	11,961	335,213	159,787
La Fitte	Louisiana	10,203	11,814	155,679	64,320
Main Pass, Block 69	do	12,832	11,672	127,466	172,534
Tom O'Connor	Texas	16,183	11,620	332,684	117,989
Pegasus	do	12,131	11,219	107,488	29,512
Headlee and North	do	12,307	10,425	89,264	112,388
Borregas (all fields)	do	13,558	10,212	86,569	64,431
Cote Blanche Bay West	Louisiana	5,409	9,720	73,295	22,705
Weeks Island	do	8,247	9,638	162,406	74,594
Coalinga	California	9,895	9,387	587,206	75,096
Sand Hills	Texas	12,579	9,231	154,365	42,635
Webster	do	11,217	9,204	310,644	139,356
Bayou Sale	Louisiana	9,767	9,070	131,504	68,506
Quarantine Bay	do	8,768	9,017	115,847	35,153
Bay St. Elaine	do	9,023	8,912	104,457	48,543
Aneth	Utah	9,803	8,891	212,148	239,852
Belridge South	California	8,070	8,889	141,606	71,112
Conroe	Texas	10,709	8,784	449,484	155,080
Russell and North	do	8,298	8,678	93,846	36,154
Levelland	do	11,104	8,491	174,679	76,017
Ventura	California	9,023	8,405	732,088	79,521
Cowden (and Foster and Johnson)	Texas	12,188	8,375	245,854	74,146
Thompson (all)	do	9,786	8,364	292,823	52,177
Fairway	do	8,637	8,316	42,129	159,014
Diamond M	do	10,999	8,281	155,576	339,424
Agua Dulce-Stratton	do	8,333	8,206	214,316	46,684
Cowden, North	do	10,268	7,987	216,180	43,820
Cogdell Area	do	10,279	7,948	121,511	55,352
Keystone	do	10,518	7,945	233,525	69,475
Empire Abo	New Mexico	6,980	7,903	52,312	47,688
McElroy	Texas	12,239	7,846	258,724	91,276
Van and Van Shallow	do	8,827	7,836	340,887	65,113
Katy, North	do	9,048	7,708	38,263	43,244
Yates	do	8,462	7,650	519,526	132,349
Coyanosa	do	3,000	7,600	17,156	27,611
Old Illinois	Illinois	9,958	7,538	650,490	24,510
Burbank	Oklahoma	8,795	7,537	474,213	25,787
Venice	Louisiana	7,220	7,128	128,992	56,472
Coalinga Nose	California	8,060	7,085	440,910	78,618
Kelsey (all fields)	Texas	8,121	7,068	82,471	43,771
Midland Farms (all)	do	11,182	7,066	143,939	67,880

[1] Fields under 7 million barrels not shown for current year.
[2] Includes revisions, if any.
Source: Oil and Gas Journal. All figures are preliminary.

Table 9.—Well completions in the United States, by quarters[1]

	1st quarter	2nd quarter	3rd quarter	4th quarter	Total	
					Number	Percent
1967						
Oil	3,400	3,487	3,540	4,902	15,329	47.5
Gas[2]	891	841	783	1,144	3,659	11.4
Dry	2,799	2,983	3,090	4,374	13,246	41.1
Total	7,090	7,311	7,413	10,420	32,234	100.0
1968						
Oil	2,793	3,567	3,785	4,197	14,342	46.8
Gas[2]	760	790	846	1,059	3,455	11.3
Dry	2,536	2,911	3,423	3,954	12,824	41.9
Total	6,089	7,268	8,054	9,210	30,621	100.0

[1] Excludes service wells.
[2] Includes condensate wells.

Source: American Association of Petroleum Geologists and American Petroleum Institute, except for 1968, which includes some Bureau of Mines data for California.

Table 10.—Well completions in the United States, by States and districts[1]

State and district	1967				1968			
	Oil	Gas[2]	Dry	Total	Oil	Gas[2]	Dry	Total
Alabama	9	------	29	38	9	1	22	32
Alaska	37	4	33	74	77	7	20	104
Arizona	6	2	16	24	4	------	6	10
Arkansas	132	70	205	407	103	46	173	322
California	2,045	72	417	2,534	2,202	76	463	2,741
Colorado	145	45	349	539	108	50	336	494
Florida	------	------	11	11	3	------	10	13
Illinois	598	1	590	1,189	544	1	497	1,042
Indiana	148	5	321	474	122	14	201	337
Iowa	------	------	1	1	------	------	------	------
Kansas	1,264	147	1,796	3,207	1,210	90	1,735	3,035
Kentucky	528	200	816	1,544	383	205	693	1,281
Louisiana:								
North	325	175	605	1,105	310	143	489	942
South	464	164	556	1,184	560	210	681	1,451
Offshore	372	126	357	855	476	184	388	1,048
Total	1,161	465	1,518	3,144	1,346	537	1,558	3,441
Michigan	65	26	273	364	73	28	269	370
Mississippi	226	15	474	715	161	12	506	679
Missouri	------	------	4	4	12	------	4	16
Montana	194	22	338	554	319	40	506	865
Nebraska	42	1	136	179	64	------	221	285
Nevada	1	------	8	9	------	------	------	------
New Mexico:								
West	52	231	62	345	30	127	45	202
East	542	26	178	746	482	23	190	695
Total	594	257	240	1,091	512	150	235	897
New York	163	13	35	211	83	10	13	106
North Dakota	72	------	81	153	49	------	134	183
Ohio	792	214	255	1,261	726	230	207	1,163
Oklahoma	1,377	443	1,032	2,852	1,323	370	1,047	2,740
Oregon	------	------	1	1	------	------	------	------
Pennsylvania	273	271	79	623	472	253	70	795
South Dakota	------	------	4	4	------	------	4	4
Tennessee	3	1	43	47	------	6	20	26
Texas:								
Gulf Coast	587	213	621	1,421	499	198	722	1,419
West	1,600	170	636	2,406	1,434	160	610	2,204
East	324	78	272	674	227	67	289	583
Panhandle	251	88	72	411	187	74	79	340
Rest of State	1,965	403	1,856	4,224	1,432	264	1,372	3,068
Total	4,727	952	3,457	9,136	3,779	763	3,072	7,614
Utah	59	10	73	142	38	5	56	99
Washington	------	------	3	3	------	------	2	2
West Virginia	269	384	121	774	119	522	92	733
Wyoming	399	39	487	925	501	39	652	1,192
Total United States	15,329	3,659	13,246	32,234	14,342	3,455	12,824	30,621

[1] Excludes service wells.

[2] Includes condensate wells.

Source: American Association of Petroleum Geologists and American Petroleum Institute, except California for 1968 which includes some Bureau of Mines data.

Table 11.—Producing oil wells in the United States and average production per well per day, by States

State	1967		1968	
	Approximate number of producing oil wells, Dec. 31	Average production per well per day (barrels)[1]	Approximate number of producing oil wells, Dec. 31	Average production per well per day (barrels)[1]
Alabama	532	38.1	[2] 546	38.7
Alaska	94	961.4	163	1,407.7
Arizona	20	616.2	22	438.5
Arkansas	6,459	9.0	6,445	8.2
California	41,608	23.7	41,360	24.7
Colorado	1,730	45.3	1,825	49.1
Illinois	27,887	5.7	27,236	5.6
Indiana	[2] 4,831	5.5	[2] 4,330	5.2
Kansas	47,597	5.8	45,145	5.6
Kentucky	13,255	3.0	[2] 12,311	3.0
Louisiana:				
Gulf Coast	16,867	117.1	16,486	125.6
Northern	13,803	10.7	13,780	10.1
Total	30,670	68.7	30,266	73.3
Michigan	4,004	9.2	4,273	8.6
Mississippi	2,557	61.3	2,599	62.2
Montana	3,390	27.8	3,385	39.1
Nebraska	1,430	24.9	1,403	25.4
New Mexico:				
Southeastern	15,210	20.9	15,323	21.1
Northwestern	1,535	19.9	1,580	18.2
Total	16,745	20.8	16,903	20.9
New York	r 4,712	r 1.1	4,201	.9
North Dakota	2,063	r 34.0	2,075	33.1
Ohio	14,638	1.9	15,480	2.0
Oklahoma	80,970	7.8	81,052	7.5
Pennsylvania	[2] 45,426	.3	42,500	.3
South Dakota	28	20.3	27	18.6
Texas:				
Gulf Coast	18,925	31.0	18,367	32.7
East Texas Field	16,328	8.6	15,902	9.0
West Texas	66,002	21.5	65,314	22.1
Panhandle	13,862	6.8	13,627	6.6
Rest of State	76,884	10.4	74,712	10.5
Total	192.001	15.8	187,922	16.3
Utah	869	75.9	875	78.6
West Virginia	12,989	.7	13,049	.7
Wyoming	8,547	44.0	8,305	46.8
Other States:				
Florida	41	103.5	44	94.8
Missouri	146	1.4	128	1.3
Nevada	13	66.5	13	57.0
Tennessee	33	.6	32	.5
Virginia	4	2.7	5	1.8
Total	237	22.4	222	21.7
Total United States	r 565,289	r 15.3	553,920	16.2

r Revised.

[1] Based on the average number of wells during the year.

[2] Compiled by Bureau of Mines (all other data on number of producing oil wells furnished by State agencies).

Table 12.—Daily average demand for crude petroleum (including lease condensate) in the United States, by States of origin and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1967													
Alabama	12.3	24.0	17.8	30.0	20.8	18.1	16.6	13.7	15.8	22.7	29.5	17.6	19.8
Alaska	34.0	69.6	57.4	39.2	59.8	79.2	75.8	72.2	89.9	112.9	120.2	85.9	74.6
Arizona	.4	.8	2.3	5.7	9.1	9.3	8.5	9.8	12.8	10.6	11.7	9.5	7.6
Arkansas	57.3	59.6	61.3	54.7	61.7	55.8	59.4	58.9	49.8	55.2	59.5	58.2	57.6
California	912.8	914.9	915.4	947.7	978.9	978.5	951.0	1,011.6	992.5	1,015.3	988.0	974.3	965.4
Colorado	95.6	99.6	80.7	73.8	112.2	106.9	91.5	96.2	101.0	86.4	81.1	103.6	94.0
Florida	6.1	6.7	.2	10.3	2.7	-------	3.1	9.5	5.7	.7	5.9	1.3	4.3
Illinois	150.8	159.6	157.4	169.9	168.9	147.0	219.7	127.0	166.0	175.0	155.8	159.0	163.1
Indiana	29.1	30.6	26.9	25.0	28.3	28.1	23.9	37.2	21.7	29.1	28.9	24.5	27.8
Kansas	257.0	268.5	301.5	246.0	259.3	283.7	293.4	281.3	262.3	270.5	248.4	269.2	269.8
Kentucky	40.7	49.9	47.4	39.0	38.1	55.9	37.0	45.9	31.9	43.4	48.9	40.1	43.1
Louisiana	1,902.3	2,072.5	2,038.0	2,024.2	1,968.2	1,994.4	2,196.0	2,288.4	2,285.5	2,237.2	2,198.5	2,260.6	2,122.5
Michigan	39.6	37.5	38.5	37.1	37.6	35.6	31.2	34.7	45.6	33.2	42.0	37.4	37.5
Mississippi	142.6	177.1	161.3	131.3	159.2	172.2	165.2	153.0	152.3	168.7	159.5	152.8	157.8
Missouri	.2	.2	.2	.2	.2	.2	.2	.3	.2	.2	.2	.2	.2
Montana	75.4	101.9	94.7	86.0	80.9	93.4	106.1	81.8	109.7	103.2	93.9	111.8	94.8
Nebraska	41.5	23.4	54.6	39.1	22.0	38.8	42.3	31.4	41.9	42.5	33.7	31.8	37.0
Nevada	.9	.6	.8	.9	.8	.8	.7	.6	.4	1.0	.8	.9	.8
New Mexico	348.8	345.0	315.9	363.7	353.4	348.5	319.0	325.7	353.2	329.3	359.5	355.6	343.0
New York	5.0	5.2	5.6	5.6	5.9	5.7	5.7	5.6	5.4	5.2	5.0	5.0	5.4
North Dakota	73.2	75.4	73.5	61.0	34.7	65.9	78.7	74.9	70.4	75.8	79.7	76.1	69.9
Ohio	25.5	24.9	30.3	27.5	30.9	23.8	26.8	28.0	28.2	28.9	30.4	26.4	27.7
Oklahoma	644.6	648.8	672.3	568.3	626.4	658.5	642.8	647.2	620.5	676.6	597.5	630.7	636.4
Pennsylvania	10.8	9.1	9.9	10.0	8.6	12.9	7.0	5.9	12.2	11.4	10.4	14.3	10.2
South Dakota	.6	.8	.6	.6	.5	.6	.6	.6	.6	.6	.6	.6	.6
Tennessee	.0	-------	.0	-------	.0	-------	.0	.0	.0	-------	.0	-------	.0
Texas	2,949.0	2,953.8	2,866.0	2,835.1	2,906.3	2,973.1	3,274.8	3,294.0	3,278.5	3,121.4	3,149.1	3,286.3	3,075.1
Utah	58.9	71.6	68.9	61.9	72.7	68.2	60.8	66.0	70.6	67.3	66.4	58.9	66.0
Virginia	-------	-------	-------	.0	-------	.0	-------	-------	-------	-------	-------	.0	.0
West Virginia	12.4	8.7	9.7	10.7	6.3	12.9	7.7	8.5	13.0	6.6	9.4	7.1	9.4
Wyoming	323.4	317.5	322.2	327.8	347.5	411.2	449.8	421.6	449.8	330.9	341.7	363.6	367.5
Total domestic crude	8,250.8	8,557.8	8,431.3	8,232.3	8,401.9	8,679.2	9,195.3	9,231.5	9,287.4	9,061.8	8,951.2	9,163.3	8,788.9
Foreign crude	1,246.9	1,043.7	1,140.3	1,228.4	1,201.7	1,222.3	1,102.8	1,046.8	998.7	1,036.9	1,045.4	1,121.5	1,120.2
Grand total 1967	9,497.7	9,601.5	9,571.6	9,460.7	9,603.6	9,901.5	10,298.1	10,278.3	10,286.1	10,098.7	9,996.6	10,284.8	9,909.1
Pennsylvania grade (included in total domestic crude above)	35.0	29.4	31.9	32.5	28.3	35.4	28.5	26.4	37.2	31.0	31.3	33.0	31.6
1968													
Alabama	22.7	16.0	20.7	23.4	15.9	20.5	18.3	20.0	31.9	20.1	22.1	18.7	20.8
Alaska	178.6	139.7	154.4	149.5	189.8	238.2	164.4	196.3	180.3	165.8	215.8	186.4	180.0
Arizona	10.7	11.9	11.0	10.4	9.1	8.8	8.5	8.2	8.8	8.3	7.9	7.8	9.3

Table 12.—Daily average demand for crude petroleum (including lease condensate) in the United States, by States of origin and months—Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Arkansas	56.4	55.0	50.4	55.8	55.7	55.5	49.9	51.4	51.4	51.8	54.2	52.5	53.3
California	949.5	929.2	1,038.0	1,079.2	1,076.9	1,085.5	1,046.1	1,029.9	1,080.7	1,033.0	966.5	998.9	1,022.3
Colorado	92.7	84.3	93.7	92.4	79.3	85.9	87.8	95.4	82.2	80.6	80.0	84.4	86.6
Florida	5.5	1.1	6.4	3.0	5.4	2.4	6.5	.7	4.0	3.8	6.3	4.0	4.1
Illinois	180.7	150.7	158.4	124.8	144.9	155.0	156.2	166.8	172.7	159.2	147.9	160.7	156.6
Indiana	24.2	24.3	22.0	22.5	22.7	23.9	24.0	26.4	21.6	22.4	24.1	19.8	23.2
Kansas	276.2	282.9	239.8	257.5	249.1	267.1	242.5	270.6	259.7	255.0	254.7	265.3	259.9
Kentucky	42.8	48.6	32.9	38.9	33.6	30.6	42.5	38.8	37.8	29.2	45.0	39.9	37.9
Louisiana	2,129.4	2,362.3	2,191.9	2,227.7	2,285.7	2,196.3	2,301.5	2,069.5	2,120.9	2,182.8	2,099.2	2,313.2	2,206.4
Michigan	37.1	38.4	34.1	35.3	34.8	34.2	37.8	34.6	30.9	37.1	38.0	37.2	35.7
Mississippi	158.0	147.6	149.3	167.6	153.6	168.7	122.4	153.5	163.3	129.1	189.6	134.7	152.5
Missouri	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Montana	116.0	120.0	100.8	116.9	135.2	124.6	172.1	145.9	145.0	133.8	133.9	133.3	131.5
Nebraska	39.2	41.2	43.8	20.3	43.4	31.1	45.4	33.4	44.3	31.8	30.8	39.3	37.0
Nevada	.9	.9	.8	.8	.6	.6	.6	.5	.9	.8	.8	.8	.7
New Mexico	360.9	359.6	356.4	320.6	346.4	343.1	340.6	377.1	328.0	367.2	386.2	349.6	353.0
New York	4.4	4.3	4.2	4.2	4.3	4.2	4.3	5.3	4.0	3.9	3.6	3.6	4.2
North Dakota	64.7	70.9	71.4	69.5	64.4	71.1	67.0	69.0	65.7	70.8	71.2	69.9	68.8
Ohio	29.5	27.8	27.1	29.1	31.4	31.2	27.0	32.5	31.4	35.5	35.7	31.1	30.8
Oklahoma	633.4	644.4	602.2	608.4	544.6	604.4	599.7	628.2	597.9	591.8	599.9	603.7	604.7
Pennsylvania	17.8	10.4	12.5	12.3	7.4	10.7	9.4	8.7	12.1	14.0	10.0	17.4	11.9
South Dakota	.5	.6	.5	.6	.5	.6	.5	.5	.5	.5	.5	.4	.5
Tennessee	-------	.0	-------	.0	-------	.0	-------	.0	-------	.0	-------	.0	.0
Texas	3,204.8	3,275.6	3,168.2	3,047.6	3,204.7	3,066.4	3,087.3	3,112.9	2,994.6	3,021.3	2,856.0	3,006.6	3,086.8
Utah	51.3	59.8	61.5	55.5	77.1	57.6	65.5	60.1	65.7	64.3	65.0	72.3	63.0
Virginia	-------	-------	-------	.0	-------	-------	-------	.0	-------	-------	-------	.0	.0
West Virginia	9.8	10.7	7.9	9.7	9.2	8.6	10.0	9.2	9.1	9.0	9.0	9.6	9.3
Wyoming	370.9	373.4	362.8	395.7	406.9	377.8	444.1	463.7	446.1	392.9	353.0	368.4	396.5
Total domestic crude	9,068.8	9,286.8	9,018.3	8,979.4	9,232.3	9,049.8	9,181.6	9,109.3	8,991.7	8,916.0	8,707.1	9,029.7	9,047.5
Foreign crude	1,073.7	997.5	1,072.2	1,051.4	1,183.3	1,338.7	1,421.8	1,399.7	1,476.4	1,366.4	1,446.2	1,465.0	1,275.3
Grand total 1968	10,142.5	10,284.3	10,090.5	10,030.8	10,415.6	10,388.5	10,603.4	10,509.0	10,468.1	10,282.4	10,153.3	10,494.7	10,322.8
Pennsylvania grade (included in total domestic crude above)	38.1	28.7	30.5	32.0	26.4	28.9	30.9	29.4	32.5	32.9	28.2	38.1	31.4

Table 13.—Indicated demand for crude petroleum (including lease condensate) in the United States, by States of origin and months

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1967													
Alabama	380	673	553	900	645	542	514	425	474	702	884	546	7,238
Alaska	1,055	1,950	1,779	1,176	1,853	2,375	2,849	2,238	2,698	3,499	3,604	2,663	27,239
Arizona	12	23	72	172	282	280	262	304	385	331	351	295	2,769
Arkansas	1,776	1,668	1,900	1,640	1,912	1,673	1,842	1,827	1,495	1,711	1,785	1,804	21,033
California	28,296	25,616	28,378	28,433	30,347	29,355	29,480	31,360	29,775	31,474	29,641	30,204	352.359
Colorado	2,965	2,788	2,501	2,213	3,477	3,208	2,837	2,981	3,029	2,679	2,433	3,212	34,323
Florida	190	187	7	308	85	-------	96	293	171	23	176	39	1,575
Illinois	4,676	4,469	4,878	5,098	5,237	4,411	6,810	3,987	4,982	5,424	4,675	4,928	59,525
Indiana	901	857	833	751	878	842	741	1,153	652	901	866	760	10,135
Kansas	7,967	7,518	9,347	7,382	8,037	8,512	9,094	8,720	7,869	8,385	7,308	8,345	98,479
Kentucky	1,262	1,398	1,469	1,170	1,182	1,677	1,148	1,424	957	1,346	1,466	1,244	15,743
Louisiana	58,972	58,030	63,177	60,728	61,013	59,832	68,077	70,939	68,567	69,352	65,956	70,079	774,722
Michigan	1,227	1,051	1,194	1,113	1,166	1,069	967	1,076	1,367	1,029	1,260	1,160	13,679
Mississippi	4,421	4,960	5,000	3,938	4,986	5,165	5,120	4,743	4,568	5,231	4,785	4,737	57,604
Missouri	6	6	6	6	6	6	7	8	5	6	6	6	74
Montana	2,338	2,852	2,937	2,579	2,508	2,801	3,288	2,537	3,290	3,200	2,817	3,466	34,613
Nebraska	1,287	655	1,694	1,174	682	1,163	1,312	978	1,256	1,316	1,010	985	13,507
New Mexico	10,812	9,660	9,792	10,911	10,956	10,456	9,889	10,097	10,595	10,209	10,786	11,024	125,187
New York	155	146	175	167	182	172	176	172	161	162	150	154	1,972
Nevada	27	18	23	25	26	23	22	20	13	30	24	28	279
North Dakota	2,269	2,111	2,278	1,830	1,077	1,977	2,441	2,323	2,113	2,349	2,391	2,360	25,519
Ohio	789	698	938	825	958	713	829	868	846	896	912	819	10,091
Oklahoma	19,982	18,166	20,842	17,049	19,417	19,757	19,928	20,063	18,615	20,976	17,926	19,553	232,274
Pennsylvania	336	254	307	299	265	386	218	183	365	354	312	444	3,723
South Dakota	20	21	18	17	15	16	18	18	16	18	17	17	211
Tennessee	1	-------	1	-------	1	-------	1	1	1	-------	1	-------	7
Texas	91,418	82,707	88,845	85,053	90,095	89,195	101,520	102,114	98,355	96,764	94,474	101,874	1,122,414
Utah	1,827	2,005	2,137	1,857	2,254	2,046	1,884	2,046	2,118	2,087	1,992	1,825	24,078
Virginia	-------	-------	-------	1	-------	1	-------	-------	-------	-------	-------	1	3
West Virginia	383	244	301	321	196	388	239	263	390	203	282	220	3,430
Wyoming	10,026	8,890	9,988	9,834	10,772	12,335	13,945	13,071	13,495	10,259	10,252	11,271	134,138
Total domestic crude	255,776	239,621	261,370	246,970	260,460	260,376	285,054	286,177	278,623	280,916	268,537	284,068	3,207,948
Foreign crude	38,653	29,223	35,351	36,852	37,253	36,668	34,187	32,452	29,960	32,148	31,362	34,765	408,869
Grand total 1967	294,429	268,844	296,721	283,822	297,713	297,044	319,241	318,629	308,588	313,059	299,899	318,828	3,616,812
Daily average:													
Domestic crude	8,251	8,558	8,431	8,232	8,402	8,679	9,195	9,232	9,287	9,062	8,951	9,163	8,789
Domestic and foreign crude	9,498	9,602	9,572	9,461	9,604	9,901	10,298	10,278	10,286	10,099	9,997	10,285	9,909
Pennsylvania grade (included in total domestic above)	1,084	824	988	975	876	1,063	883	819	1,115	960	939	1,024	11,550

Table 13.—Indicated demand for crude petroleum (including lease condensate) in the United States, by States of origin and months—Continued

(Thousand barrels)

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1968													
Alabama	702	465	643	701	493	615	566	621	957	624	662	578	7,627
Alaska	5,537	4,050	4,787	4,485	5,883	7,147	5,097	6,086	5,409	5,141	6,475	5,778	65,875
Arizona	330	344	341	312	282	264	262	254	265	257	238	241	3,390
Arkansas	1,748	1,594	1,561	1,675	1,726	1,666	1,548	1,595	1,541	1,607	1,627	1,628	19,516
California	29,435	26,948	32,177	32,376	33,384	31,066	32,429	31,927	32,421	32,022	28,996	30,967	374,148
Colorado	2,873	2,444	2,904	2,772	2,459	2,576	2,722	2,957	2,467	2,498	2,400	2,617	31,689
Florida	171	33	197	91	167	72	203	23	121	116	188	124	1,506
Illinois	5,601	4,370	4,910	3,745	4,492	4,649	4,841	5,170	5,181	4,936	4,436	4,983	57,314
Indiana	751	705	683	674	704	718	743	817	647	694	723	612	8,471
Kansas	8,561	8,203	7,433	7,725	7,723	8,012	7,516	8,388	7,792	7,905	7,640	8,225	95,123
Kentucky	1,327	1,265	1,019	1,166	1,041	919	1,319	1,202	1,133	905	1,350	1,237	13,883
Louisiana	66,010	68,506	67,950	66,832	70,858	65,889	71,346	64,153	63,628	67,668	62,976	71,708	807,524
Michigan	1,149	1,115	1,057	1,058	1,063	1,026	1,157	1,073	927	1,149	1,140	1,153	13,067
Mississippi	4,899	4,279	4,629	5,028	4,761	4,912	3,794	4,757	4,898	4,008	5,687	4,175	55,822
Missouri	7	7	6	5	5	6	5	5	5	5	5	5	66
Montana	3,597	3,480	3,124	3,508	4,191	3,737	5,336	4,522	4,349	4,147	4,017	4,132	48,140
Nebraska	1,216	1,194	1,359	609	1,344	933	1,408	1,036	1,330	987	925	1,217	13,558
Nevada	29	25	24	22	18	19	18	16	28	24	24	24	271
New Mexico	11,189	10,429	11,047	9,618	10,739	10,292	10,560	11,689	9,841	11,383	11,586	10,836	129,209
New York	136	124	130	125	132	125	132	165	120	122	109	112	1,532
North Dakota	2,006	2,056	2,213	2,086	1,998	2,132	2,077	2,140	1,970	2,195	2,136	2,168	25,177
Ohio	915	807	840	873	973	937	836	1,006	942	1,101	1,070	964	11,264
Oklahoma	19,636	18,689	18,669	18,252	16,883	18,131	18,591	19,478	17,937	18,347	17,998	18,716	221,322
Pennsylvania	550	301	389	370	228	322	291	271	363	433	301	540	4,359
South Dakota	16	16	16	16	17	17	16	15	15	16	14	13	187
Tennessee	-------	1	-------	1	-------	1	-------	1	-------	1	-------	1	6
Texas	99,350	94,992	98,058	91,428	99,347	91,992	95,707	96,500	89,838	93,659	85,681	93,205	1,129,757
Utah	1,591	1,735	1,907	1,665	2,389	1,728	2,031	1,863	1,970	1,993	1,949	2,242	23,063
Virginia	-------	-------	-------	1	-------	-------	-------	1	-------	-------	-------	1	3
West Virginia	303	309	246	292	285	257	311	286	273	279	269	298	3,408
Wyoming	11,497	10,830	11,248	11,870	12,615	11,334	13,766	14,376	13,384	12,180	10,591	11,421	145,112
Total domestic crude	281,132	269,316	279,567	269,381	286,200	271,494	284,628	282,388	269,752	276,397	261,213	279,921	3,311,389
Foreign crude	33,284	28,928	33,237	31,542	36,684	40,162	44,076	43,392	44,291	42,358	43,385	45,414	466,753
Grand total 1968	314,416	298,244	312,804	300,923	322,884	311,656	328,704	325,780	314,043	318,755	304,598	325,335	3,778,142
Daily average:													
Domestic crude	9,069	9,287	9,018	8,979	9,232	9,050	9,182	9,109	8,992	8,916	8,707	9,030	9,048
Domestic and foreign crude	10,142	10,284	10,090	10,031	10,416	10,389	10,603	10,509	10,468	10,282	10,153	10,495	10,328
Pennsylvania grade (included in total domestic above)	1,182	833	947	959	818	868	957	912	964	1,021	846	1,180	11,497

Table 14.—Receipts of domestic and foreign crude petroleum at refineries in the United States

(Million barrels)

Method of transportation	1964	1965	1966	1967	1968 p
By water:					
Intrastate	125.9	147.3	152.0	129.1	136.8
Interstate	285.9	296.6	347.7	428.4	428.8
Foreign	337.1	344.4	320.7	265.3	303.0
Total	748.9	788.3	820.4	822.8	868.6
By pipeline:					
Intrastate	1,426.0	1,407.0	1,465.8	1,581.1	1,673.0
Interstate	929.4	955.8	996.2	995.9	1,023.7
Foreign	101.7	107.4	126.0	146.6	169.2
Total	2,457.1	2,470.2	2,588.0	2,723.6	2,865.9
By tank cars and trucks:					
Intrastate	34.4	34.8	38.1	40.0	40.8
Interstate	4.3	3.5	4.5	5.7	6.8
Total	38.7	38.3	42.6	45.7	47.6
Grand total	3,244.7	3,296.8	3,451.0	3,592.1	3,782.1

p Preliminary.

Table 15.—Refinery receipts of domestic

(Thousand

Receiving district and State	Total domestic receipts	Intra-state receipts	Interstate receipts from—					
			Ala. and Miss.	Ark.	Calif. Nev., and Alaska	Colo.	N.Y. and Fla.	Ill.
District I:								
Delaware, Maryland	11,898	---------	------	------	------	------	1,404	------
Florida, Georgia, and Virginia	1,773	---------	1,435	------	------	------	------	------
New Jersey	68,923	---------	10,084	------	268	------	------	------
New York	4,974	---------	------	------	------	------	------	421
Pennsylvania:								
East	107,512	---------	367	------	------	------	------	------
West	17,089	4,754	------	------	------	30	1,575	93
West Virginia	2,866	1,766	------	------	------	------	------	------
Total	215,035	6,520	11,886	------	268	30	2,979	514
District II:								
Illinois	248,938	24,152	58	------	------	384	------	------
Indiana	167,607	4,429	------	------	------	1,373	------	5,477
Kansas	135,679	84,783	------	------	------	1,710	------	------
Kentucky, Tennessee	53,602	9,957	1,675	------	------	------	[1] 12	8,847
Michigan	38,898	12,649	------	------	------	------	------	1,940
Minnesota, Wisconsin	6,683	---------	------	------	------	------	------	------
Missouri, Nebraska	28,688	---------	------	------	------	------	------	------
North Dakota	18,486	17,780	------	------	------	------	------	------
Ohio:								
East	20,981	6,583	------	------	------	2,526	------	7,021
West	126,192		4,126	------	------	4,156	------	15,879
Oklahoma	159,408	119,530	------	------	------	1,347	------	------
Total	1,005,162	279,863	5,859	------	------	11,496	12	39,164
District III:								
Alabama	6,577	1,256	3,296	------	------	------	1	------
Arkansas	29,092	18,102	------	------	------	------	------	------
Louisiana	399,245	339,006	25,409	306	------	------	------	------
Mississippi	61,743	11,994	------	------	------	------	------	------
New Mexico	13,422	13,422	------	------	------	------	------	------
Texas	999,812	735,130	2,822	------	------	------	------	98
Total	1,509,891	1,118,910	31,527	306	------	------	1	98
District IV:								
Colorado	13,169	1,583	------	------	------	------	------	------
Montana	31,043	10,959	------	------	------	------	------	------
Utah	36,722	10,303	------	------	165	18,394	------	------
Wyoming	43,342	42,209	------	------	------	1,068	------	------
Total	124,276	65,054	------	------	165	19,462	------	------
District V:								
California	432,567	372,912	197	------	[4] 44,847	------	------	------
Other States [3]	22,931	7,327	------	------	15,604	------	------	------
Total	455,498	380,239	197	------	60,451	------	------	------
Total United States	3,309,862	1,850,586	49,469	306	60,884	30,988	2,992	39,776
Daily average	9,043	5,056	135	1	166	85	8	109

---

[1] Oil from Virginia.
[2] Includes 12,000 barrels from Tennessee.

crude oil, by States and districts in 1968

barrels)

Interstate receipts from—												
Ind. and Mich.	Kans.	Ohio and Ky.	La.	Mont.	Nebr., N. Dak. and S. Dak.	New Mex.	Okla.	Texas	Utah	W. Va.	Wyo.	Total receipts
------	------	------	2,768	------	------	------	------	7,726	------	------	------	11,898
------	------	------	69	------	------	------	------	269	------	------	------	1,773
------	------	------	40,828	------	------	------	------	17,743	------	------	------	68,923
------	------	28	220	180	------	------	3,704	421	------	------	------	4,974
------	------	------	53,095	------	------	213	------	53,837	------	------	------	107,512
------	------	3,330	------	4,684	31	------	754	------	------	1,838	------	12,335
------	------	1,100	------	------	------	------	------	------	------	------	------	1,100
------	------	4,458	96,980	4,864	31	213	4,458	79,996	------	1,838	------	208,515
519	5,316	------	15,252	3,158	302	27,737	30,497	126,816	500	------	14,247	224,786
208	11,115	4	1,671	10,549	4,902	16,715	29,381	48,381	------	------	33,402	163,178
------	------	------	------	2,293	1,496	6,695	17,057	14,914	------	------	6,731	50,896
------	------	[3] 68	33,043	------	------	------	------	------	------	------	------	43,645
------	------	------	------	667	------	------	------	14,455	------	------	9,187	26,249
------	------	------	------	------	6,680	------	------	------	------	------	3	6,683
------	2,390	------	------	------	------	10,115	1,179	8,335	------	------	6,669	28,688
------	------	------	------	706	------	------	------	------	------	------	------	706
------	216	------	2,017	------	------	------	186	------	------	------	2,453	14,419
------	449	------	39,249	------	3,515	2,224	6,665	43,507	------	------	6,401	126,171
------	3,948	------	1,203	------	------	4,848	------	27,741	791	------	------	39,878
727	23,434	72	92,435	17,373	16,895	68,334	84,965	284,149	1,291	------	79,093	725,299
------	------	------	2,024	------	------	------	------	------	------	------	------	5,321
------	------	------	3,682	------	------	------	------	7,308	------	------	------	10,990
------	------	------	------	------	------	------	42	34,482	------	------	------	60,239
------	------	------	49,749	------	------	------	------	------	------	------	------	49,749
------	------	------	------	------	------	------	------	------	------	------	------	------
------	6	------	217,456	------	------	40,728	1,108	------	2,464	------	------	264,682
------	6	------	272,911	------	------	40,728	1,150	41,790	2,464	------	------	[4] 390,981
------	------	------	------	1,413	------	9	------	------	6	------	10,158	11,586
------	------	------	------	------	------	------	------	------	------	------	20,084	20,084
------	------	------	------	------	------	123	------	------	------	------	7,737	26,419
------	------	------	------	54	11	------	------	------	------	------	------	1,133
------	------	------	------	1,467	11	132	------	------	6	------	37,979	59,222
------	------	------	------	------	------	5,706	------	------	8,905	------	------	59,655
------	------	------	------	------	------	------	------	------	------	------	------	15,604
------	------	------	------	------	------	5,706	------	------	8,905	------	------	75,259
727	23,440	4,530	462,326	23,704	16,937	115,113	90,573	405,935	12,666	1,838	117,072	1,459,276
2	64	12	1,263	65	46	315	247	1,109	35	5	320	3,987

[3] Alaska, Hawaii, Oregon, and Washington.
[4] Includes 3,390,000 barrels from Arizona.

Table 16.—Crude runs to stills and refinery receipts of crude oil, by origin of the crude and method of transportation in 1968

(Thousand barrels)

District and State	Crude runs to stills	Refinery fuel use and losses	Refinery receipts of domestic crude—								Refinery receipts of foreign crude	
			By State of origin of domestic crude	Change in refinery stocks	By receiving State and method of transportation							
					Intrastate			Interstate				
					Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tank cars and trucks	Tankers and barges	Pipelines	Tankers and barges
District I:												
Delaware, Maryland	37,232	—12	---------	—208	---------	---------	---------	---------	---------	11,898	---------	25,114
Florida, Georgia, Virginia	15,632	---------	1,417	+667	---------	---------	---------	---------	468	1,305	---------	14,526
New Jersey	178,313	9	---------	+1,362	---------	---------	---------	---------	---------	68,923	---------	110,761
New York	26,341	---------	1,575	—58	---------	---------	---------	4,974	---------	---------	21,309	---------
Pennsylvania:												
East	199,587	215	---------	—134	---------	---------	---------	---------	---------	107,512	---------	92,156
West	17,109	3	4,754	—23	4,596	158	---------	10,123	1,127	1,085	---------	---------
West Virginia	2,862	7	3,604	—3	1,625	141	---------	742	358	---------	---------	---------
Total	[1] 477,076	222	11,350	+1,603	6,221	299	---------	15,839	1,953	190,723	21,309	242,557
District II:												
Illinois	248,736	113	63,928	+244	24,053	99	---------	224,786	---------	---------	155	---------
Indiana	167,469	11	4,948	+127	3,842	587	---------	162,966	212	---------	---------	---------
Kansas	135,792	44	108,223	—157	82,378	2,405	---------	50,872	24	---------	---------	---------
Kentucky, Tennessee	53,718	28	9,969	—144	3,469	230	6,258	11,540	24	32,081	---------	---------
Michigan	53,525	9	12,857	—175	10,946	1,703	---------	26,249	---------	---------	14,461	---------
Minnesota, Wisconsin	49,032	32	---------	+22	---------	---------	---------	6,683	---------	---------	42,403	---------
Missouri, Nebraska	28,716	---------	10,249	—28	---------	---------	---------	28,688	---------	---------	---------	---------
North Dakota	18,518	—4	[2] 24,468	—28	17,631	149	---------	44	662	---------	---------	---------
Ohio:												
East	21,707	—1	11,101	+106	3,435	3,127	---------	14,419	---------	---------	831	---------
West	[3] 146,104	15		+617	10	11	---------	126,171	---------	---------	[3] 20,544	---------
Oklahoma	159,560	124	210,103	—217	116,186	3,344	---------	39,878	---------	---------	59	---------
Total	1,082,877	371	455,846	+367	261,950	11,655	6,258	692,296	922	32,081	78,453	---------
District III:												
Alabama	6,410	42	6,885	+125	---------	43	1,213	---------	439	4,882	---------	---------
Arkansas	29,234	7	18,408	—149	17,082	1,020	---------	10,619	371	---------	---------	---------
Louisiana	398,792	175	801,332	+919	271,238	3,768	64,000	49,538	958	9,743	---------	641
Mississippi	61,907	---------	55,834	—164	10,171	1,823	---------	49,250	---------	499	---------	---------
New Mexico	13,411	14	128,535	—3	11,539	1,883	---------	---------	---------	---------	---------	---------
Texas	997,367	109	1,141,065	+2,336	697,853	9,848	27,429	130,899	134	133,649	---------	---------
Total	1,507,121	347	2,152,059	+3,064	1,007,883	18,385	92,642	240,306	1,902	148,773	---------	641

District IV:												
Colorado	13,648	28	32,571	+23	--------	1,583	--------	11,517	69	--------	530	--------
Montana	40,370	28	34,663	+7	10,118	841	--------	20,084	--------	--------	9,362	--------
Utah	36,750	1	22,969	—29	7,478	2,825	--------	24,945	1,474	--------	--------	--------
Wyoming	43,107	33	159,281	+202	41,431	778	--------	731	402	--------	--------	--------
Total	133,875	90	249,484	+203	59,027	6,027	--------	57,277	1,945	--------	9,892	--------
District V:												
California	476,936	68	379,231	+868	330,555	4,457	37,900	18,001	106	41,548	--------	45,305
Other States [4]	96,475	24	61,892	+520	7,327	--------	--------	--------	--------	15,604	59,549	14,539
Total	573,411	92	441,123	+1,388	337,882	4,457	37,900	18,001	106	57,152	59,549	59,844
Total United States	3,774,360	1,122	3,309,862	+6,625	1,672,963	40,823	136,800	1,023,719	6,828	428,729	[5] 169,203	303,042
Daily average	10,312	3	9,043	+18	4,571	111	374	2,797	19	1,171	462	828

[1] Includes 294,459,000 barrels in Delaware River Valley.
[2] Includes 8,000 barrels from South Dakota.
[3] Includes some Athabasca hydrocarbons.
[4] Alaska, Arizona, Hawaii, Nevada, Oregon, and Washington.
[5] Excludes crude oil imported from direct fuel use by pipelines.

Table 17.—Transportation of petroleum products by pipelines in the United States, 1968, by months

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Turned into lines:													
Gasoline:													
Motor	97,685	94,104	103,333	101,036	110,936	112,716	113,814	115,412	110,805	108,548	104,319	108,238	1,280,946
Aviation	607	647	676	480	605	632	665	611	500	580	911	441	7,355
Total gasoline	98,292	94,751	104,009	101,516	111,541	113,348	114,479	116,023	111,305	109,128	105,230	108,679	1,288,301
Jet fuel:													
Naphtha type	2,208	2,188	2,655	2,414	2,026	2,087	1,994	1,938	1,993	2,404	2,149	2,202	26,258
Kerosine type	9,343	8,742	10,498	10,335	10,929	10,875	11,278	11,627	11,398	10,674	10,903	11,669	128,271
Total jet fuel	11,551	10,930	13,153	12,749	12,955	12,962	13,272	13,565	13,391	13,078	13,052	13,871	154,529
Kerosine	7,360	6,901	5,653	3,930	4,584	3,623	4,140	4,122	4,308	5,536	5,400	7,052	62,609
Distillate fuel oil	59,068	51,358	48,391	39,031	41,810	40,307	40,433	38,578	37,874	40,921	45,635	54,194	537,600
Natural gas liquids	24,152	21,190	20,351	17,811	20,656	18,844	18,537	18,697	19,216	21,236	24,007	27,986	252,683
Delivered from lines:													
Gasoline:													
Motor	95,980	93,349	101,118	102,454	110,993	111,767	115,807	116,057	110,172	109,399	106,676	108,040	1,281,812
Aviation	570	592	641	568	655	624	561	669	454	604	1,012	370	7,320
Total gasoline	96,550	93,941	101,759	103,022	111,648	112,391	116,368	116,726	110,626	110,003	107,688	108,410	1,289,132

Table 17.—Transportation of petroleum products by pipelines in the United States, 1968, by months—Continued

(Thousand barrels)

Item	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Jet fuel:													
Naphtha type	2,065	2,215	2,641	2,492	2,051	2,086	1,877	2,062	1,937	2,338	2,413	2,091	26,368
Kerosine type	9,158	8,728	10,006	10,011	10,744	10,743	11,386	11,051	11,401	10,665	11,391	11,511	126,795
Total jet fuel	11,223	10,943	12,647	12,503	12,795	12,829	13,263	13,113	13,338	13,003	13,804	13,602	153,063
Kerosine	8,307	6,426	6,286	4,074	4,115	3,731	3,837	3,862	4,213	4,680	5,702	6,986	62,219
Distillate fuel oil	61,525	54,023	50,978	39,219	40,666	37,748	38,695	36,356	36,044	39,796	47,527	55,875	538,452
Natural gas liquids	24,220	21,100	20,810	17,571	20,631	18,942	18,289	19,137	17,878	20,909	24,033	27,844	251,364
Shortage or overage :													
Gasoline:													
Motor	—256	—158	—61	—247	—111	—77	—28	—25	—9	—118	—42	—106	—1,238
Aviation	2	16	1	14	4	13	9	9	14	7	12	8	109
Total gasoline	—254	—142	—60	—233	—107	—64	—19	—16	5	—111	—30	—98	—1,129
Jet fuel:													
Naphtha type	—5	6	-------	—23	21	4	2	6	-------	—6	3	12	20
Kerosine type	89	135	69	112	102	121	124	95	94	93	107	81	1,222
Total jet fuel	84	141	69	89	123	125	126	101	94	87	110	93	1,242
Kerosine	118	111	158	102	101	64	65	83	100	105	61	143	1,211
Distillate fuel oil	59	—110	—118	—27	—51	13	—12	2	—86	-------	32	—16	—314
Natural gas liquids	164	3	77	83	48	51	14	11	98	174	20	6	749
Stocks in lines and working tanks at end of month:													
Gasoline:													
Motor	36,634	37,547	39,823	38,652	38,706	39,732	37,767	37,147	37,789	37,056	34,741	35,045	35,045
Aviation	389	428	462	360	306	301	391	329	361	330	217	280	280
Total gasoline	37,023	37,975	40,285	39,012	39,012	40,033	38,158	37,476	38,150	37,386	34,958	35,325	35,325
Jet fuel:													
Naphtha type	963	930	944	889	843	940	955	825	881	953	686	785	785
Kerosine type	2,384	2,263	2,686	2,898	2,981	2,992	2,760	3,241	3,144	3,060	2,465	2,542	2,542
Total jet fuel	3,347	3,193	3,630	3,787	3,824	3,932	3,715	4,066	4,025	4,013	3,151	3,327	3,327
Kerosine	2,304	2,668	1,877	1,631	1,999	1,827	2,065	2,242	2,237	2,988	2,625	2,548	2,548
Distillate fuel oil	23,111	20,556	18,087	17,926	19,121	21,667	23,417	25,637	27,553	28,678	26,754	25,089	25,089
Natural gas liquids	6,990	7,077	6,541	6,698	6,675	6,526	6,760	6,309	7,549	7,702	7,656	7,792	7,792

Table 18.—Transportation of petroleum products by pipeline between PAD districts in the United States, by months

(Thousand barrels)

	1968													1967 total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
From District I to District II:														
Gasoline:														
Motor	2,004	1,872	2,838	2,465	2,639	2,657	2,888	2,960	2,763	2,507	2,550	2,456	30,094	28,485
Aviation	9	10	15	12	2	21	8	3	17	2	6	8	103	156
Total gasoline	2,013	1,882	2,348	2,477	2,641	2,678	2,891	2,963	2,780	2,509	2,556	2,459	30,197	28,641
Jet fuel (kerosine-type)	79	74	39	36	60	44	64	58	57	64	64	116	755	559
Kerosine	126	94	98	80	10	45	63	------	64	89	91	77	787	719
Distillate fuel oil	501	535	537	669	628	578	572	626	540	450	586	605	6,827	6,250
From District II to District I:														
Gasoline (motor)	633	1,200	1,134	1,192	816	1,451	454	796	780	734	743	812	10,745	4,450
Distillate fuel oil	14	26	10	22	------	------	12	24	16	14	12	49	199	145
Natural gas liquids	477	667	673	622	701	253	675	707	627	739	615	681	7,437	5,584
From District II to District III:														
Gasoline:														
Motor	1,328	1,485	1,381	1,205	1,643	1,549	1,662	1,613	1,203	1,368	1,354	1,669	17,460	17,661
Aviation	12	16	15	9	------	10	14	5	10	5	------	5	101	125
Total gasoline	1,340	1,501	1,396	1,214	1,643	1,559	1,676	1,618	1,213	1,373	1,354	1,674	17,561	17,786
Jet fuel:														
Naphtha type	60	78	97	59	172	85	88	80	80	80	40	105	1,024	1,227
Kerosine type	------	------	------	------	------	------	------	------	------	------	2	------	2	2
Total jet fuel	60	78	97	59	172	85	88	80	80	80	42	105	1,026	1,229
Distillate fuel oil	637	724	427	530	357	491	463	432	232	216	431	236	5,176	4,843
Natural gas liquids	4	------	5	------	------	------	5	6	6	12	10	16	64	10
From District III to District I:														
Gasoline:														
Motor	19,068	19,852	21,498	21,561	23,824	21,667	24,565	25,076	24,171	23,784	21,550	21,598	268,214	242,304
Aviation	49	115	114	99	57	78	64	93	78	69	73	18	907	1,214
Total gasoline	19,117	19,967	21,612	21,660	23,881	21,745	24,629	25,169	24,249	23,853	21,623	21,616	269,121	243,518
Jet fuel:														
Naphtha type	129	113	162	136	165	131	110	124	106	99	170	153	1,598	1,746
Kerosine type	1,942	2,018	2,339	2,125	2,854	2,541	2,836	2,536	2,695	2,560	2,332	2,510	29,278	23,238
Total jet fuel	2,071	2,131	2,501	2,261	3,019	2,672	2,936	2,660	2,801	2,659	2,502	2,663	30,876	24,984
Kerosine	2,393	2,061	1,893	927	851	992	958	1,093	1,112	1,153	1,654	2,078	17,165	17,299
Distillate fuel oil	17,455	15,752	14,998	12,898	12,352	13,282	12,318	9,811	9,693	11,766	13,297	16,699	160,316	140,683
Natural gas liquids	1,702	1,473	898	348	865	510	665	1,012	614	727	1,171	1,585	11,070	9,012

Table 18.—Transportation of petroleum products by pipeline between PAD districts in the United States, by months—Continued

(Thousand barrels)

	1968													1967 total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
From District III to District II:														
Gasoline:														
Motor	2,850	3,996	3,086	4,251	4,150	4,309	4,391	3,599	3,649	3,588	3,412	3,594	44,875	38,213
Aviation	74	192	153	53	188	109	188	136	190	178	167	110	1,738	1,918
Total gasoline	2,924	4,188	3,239	4,304	4,338	4,418	4,579	3,735	3,839	3,766	3,579	3,704	46,613	40,131
Jet fuel (kerosine type)	------	------	140	118	105	104	115	103	226	------	94	242	1,247	123
Kerosine	207	298	106	55	95	6	28	143	38	78	62	137	1,253	2,009
Distillate fuel oil	1,616	1,283	677	538	731	743	936	1,202	1,259	892	772	1,064	11,718	11,743
Natural gas liquids	5,865	4,153	4,686	3,418	3,359	2,747	3,487	3,527	3,228	4,572	4,639	6,330	50,011	43,158
From District III to District IV:														
Gasoline:														
Motor	265	251	271	287	309	333	383	407	319	334	282	294	3,735	3,536
Aviation	18	18	23	35	28	25	25	27	23	28	22	22	294	273
Total gasoline	283	269	294	322	337	358	408	434	342	362	304	316	4,029	3,809
Jet fuel (kerosine type)	327	274	293	282	289	260	242	281	281	314	321	336	3,500	3,172
Kerosine	11	7	5	5	3	26	32	3	4	5	7	7	115	105
Distillate fuel oil	38	36	43	48	49	51	46	49	44	52	44	43	543	485
Natural gas liquids	140	85	82	69	56	36	53	53	75	64	100	145	958	927
From District III to District V:														
Gasoline (motor)	869	808	802	942	890	889	832	767	805	877	810	892	10,183	9,856
Jet fuel:														
Naphtha type	401	362	336	344	340	315	269	391	279	399	306	191	3,933	3,738
Kerosine type	142	181	225	134	241	162	251	216	244	247	245	234	2,522	2,067
Total jet fuel	543	543	561	478	581	477	520	607	523	646	551	425	6,455	5,805
Kerosine	8	9	9	------	------	------	------	------	------	7	3	6	42	32
Distillate fuel oil	204	171	274	181	305	283	264	232	213	288	240	285	2,940	2,555
From District IV to District II:														
Gasoline (motor)	255	256	226	272	305	373	362	420	333	344	264	276	3,686	3,324
Jet fuel (naphtha type)	------	------	------	------	------	------	------	------	------	------	------	------	-------	257
Kerosine	1	6	3	5	5	6	10	7	6	3	8	8	68	12
Distillate fuel oil	182	167	147	126	162	138	133	127	155	176	143	148	1,804	1,574
From District IV to District V:														
Gasoline:														
Motor	809	789	864	911	895	876	971	899	720	912	796	779	10,211	10,677
Aviation	------	------	------	5	------	------	------	------	------	------	------	------	5	-------
Total gasoline	809	789	864	916	895	876	971	889	720	912	796	779	10,216	10,677

Jet fuel:														
Naphtha type	92	108	164	13	19	12	25	33	41	102	104	128	841	1,244
Kerosine type	43	44	83	102	89	68	28	10	120	26	17	79	709	463
Total jet fuel	135	152	247	115	108	80	53	43	161	128	121	207	1,550	1,707
Kerosine	----	----	----	----	----	----	----	----	----	----	----	----	----	28
Distillate fuel oil	605	499	503	440	411	299	267	358	455	482	433	503	5,255	4,878

Table 19.—Pipeline tariff rates for crude petroleum and petroleum products, January 1

(Dollars per barrel)

Origin	Destination	1967	1968	1969
Crude oil:				
West Texas	Houston, Tex	$0.16	$0.145–$0.16	$0.14–$0.16
Do	East Chicago	.29– .31	.29 – .31	.28
Do	Wood River, Ill	.27– .28	.27 – .28	.27– .28
Oklahoma	Chicago, Ill	.22	.22	.22
Do	Wood River, Ill	.19	.19	.19
Eastern Wyoming	Chicago, Ill	.33	.32 – .33	.33
Do	Wood River, Ill	.30	.29 – .30	.30
Refined products:				
Houston, Tex	Atlanta, Ga	.249	.219– .277	.2770
Do	New York, N.Y	.348	.305	.3055
Tulsa, Okla	Minneapolis, Minn	.52	.52	.52
Salt Lake City, Utah	Spokane, Wash	.49	.48	.48
Philadelphia, Pa	Rochester, N.Y	.24	.24	.24

Source: Interstate Commerce Commission.

Table 20.—Petroleum oils, crude and refined, shipped from gulf and west coasts to east coast ports and from the gulf coast to west coast ports, by months

(Thousand barrels)

	1968													1967 total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
Gulf coast to east coast:														
Crude oil	19,409	19,888	20,615	15,057	16,034	13,891	15,557	13,954	16,118	12,260	12,716	12,511	188,280	224,105
Unfinished oils	2,114	2,792	1,204	1,286	1,140	986	1,766	1,214	715	647	543	685	15,092	21,154
Gasoline:														
Motor	13,103	10,781	13,140	15,141	13,381	12,289	14,092	11,993	12,685	13,597	11,941	11,224	153,367	158,613
Aviation	614	363	539	368	510	391	542	446	423	449	463	325	5,433	6,748
Total	13,717	11,144	13,679	15,509	13,891	12,680	14,634	12,439	13,108	14,046	12,404	11,549	158,800	165,361
Special naphthas	202	268	452	428	616	434	380	316	436	380	543	302	4,757	4,227
Kerosine	2,543	2,605	1,714	1,635	1,340	1,104	868	1,478	1,362	1,307	1,648	1,995	19,599	18,643
Distillate fuel oil	14,739	15,508	15,333	11,321	9,194	8,564	9,539	6,788	5,594	6,778	7,823	11,340	122,521	135,370
Residual fuel oil	3,533	2,474	2,426	2,898	2,283	2,712	3,128	2,803	2,815	3,063	2,900	3,950	34,985	30,461
Jet fuel:														
Naphtha type	1,542	1,132	1,344	1,275	1,343	1,214	1,610	1,342	1,073	1,420	1,408	1,187	15,890	19,830
Kerosine type	2,048	2,728	2,716	2,476	1,722	2,028	1,956	1,829	2,621	2,226	2,462	2,802	27,614	23,008
Total	3,590	3,860	4,060	3,751	3,065	3,242	3,566	3,171	3,694	3,646	3,870	3,989	43,504	42,838
Lubricating oil	742	520	660	912	933	707	936	744	925	862	729	881	9,551	9,393
Wax	15	3	3	------	15	13	------	9	3	17	------	10	88	127
Asphalt and road oil	384	151	276	590	697	454	580	592	651	583	453	535	5,946	5,274
Liquefied gases	160	129	74	110	68	61	109	125	254	262	356	386	2,094	1,737
Petrochemical feedstocks	142	233	183	306	477	224	204	136	195	345	207	401	3,053	2,416
Other products	58	110	80	70	163	135	73	106	70	164	125	264	1,418	2,135
Total	61,348	59,685	60,759	53,873	50,186	45,207	51,340	43,875	45,940	44,360	44,317	48,798	609,688	663,241
West coast to east coast:														
Crude oil	109	------	------	------	------	------	------	159	------	------	------	------	268	807
Gasoline:														
Motor	------	------	180	------	------	------	------	------	------	------	------	------	180	------
Aviation	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Total	------	------	180	------	------	------	------	------	------	------	------	------	180	------
Distillate fuel oil	------	------	------	------	------	65	------	------	------	118	------	------	183	316
Residual fuel oil	------	------	------	------	------	------	------	------	98	------	------	------	98	117
Jet fuel:														
Naphtha type	------	------	------	------	------	------	------	------	------	------	------	------	------	------
Kerosine type	------	15	------	------	------	------	------	------	------	------	------	------	15	26

Table 20.—Petroleum oils, crude and refined, shipped from gulf and west coasts to east coast ports and from the gulf coast to west coast ports, by months—Continued

(Thousand barrels)

	1968													1967 total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
Total	------	15	------	------	------	------	------	------	------	------	------	------	15	26
Lubricating oil	66	76	43	132	78	67	97	85	46	30	71	24	815	751
Other products	------	------	------	------	------	------	------	4	------	------	------	------	4	------
Total	175	91	223	132	78	132	97	248	144	148	71	24	1,563	2,017
Gulf coast to west coast:														
Crude oil	------	------	------	------	------	------	------	------	197	------	------	------	197	------
Gasoline:														
Motor	8	289	6	807	1,664	1,896	52	357	760	421	369	231	6,860	6,176
Aviation	112	94	24	14	------	178	49	------	68	------	96	49	679	2,119
Total	120	383	30	821	1,664	2,074	101	357	823	421	465	280	7,539	8,295
Special naphthas	31	------	15	------	22	6	------	22	------	15	16	16	143	157
Kerosine	------	------	------	------	1	1	------	64	------	------	------	------	66	99
Distillate fuel oil	79	145	36	129	144	161	135	76	80	61	181	136	1,363	1,116
Residual fuel oil	------	------	------	------	------	------	------	------	------	------	62	------	62	------
Jet fuel:														
Naphtha type	605	621	76	699	327	670	638	729	667	548	146	150	5,876	8,125
Kerosine type	328	347	332	205	205	329	414	435	122	269	353	264	3,603	4,271
Total	933	968	408	904	532	999	1,052	1,164	789	817	499	414	9,479	12,396
Lubricating oil	98	127	178	------	313	81	------	162	82	65	70	210	1,386	1,562
Petrochemical feedstocks	------	26	33	------	33	33	------	33	33	------	45	30	266	346
Other products	------	------	------	------	------	15	------	------	------	------	------	8	23	46
Total	1,261	1,649	700	1,854	2,709	3,370	1,288	1,878	2,004	1,379	1,338	1,094	20,524	24,017

Table 21.—Barge movements via the Mississippi river of crude oil and products from PAD District III to PAD Districts I and II, by months

(Thousand barrels)

Movements from District III to—	1968 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total	1967 total
DISTRICT I														
Gasoline:														
Motor gasoline	898	1,166	836	872	1,258	1,036	973	917	1,017	1,051	908	897	11,829	11,356
Aviation gasoline	16	21	15	16	29	16	27	25	31	37	33	7	273	309
Total	914	1,187	851	888	1,287	1,052	1,000	942	1,048	1,088	941	904	12,102	11,665
Special naphthas	17	15	-----	17	41	5	12	16	7	5	17	-----	152	211
Kerosine	52	92	21	4	-----	16	61	35	27	68	85	61	522	360
Distillate fuel oil	81	162	65	88	147	196	96	95	81	154	162	125	1,452	1,332
Residual fuel oil	56	28	117	49	15	-----	19	-----	48	-----	-----	-----	332	347
Jet fuel:														
Naphtha type	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	34
Kerosine type	58	89	16	92	17	31	49	17	51	69	52	50	591	696
Total	58	89	16	92	17	31	49	17	51	69	52	50	591	730
Lubricating oil	137	194	143	152	146	121	176	153	183	109	220	165	1,899	1,818
Wax	2	-----	3	-----	2	-----	-----	3	-----	5	-----	1	16	40
Asphalt and road oil	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------
Liquefied gases	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	------
Petrochemical feedstocks	18	7	38	37	45	18	21	4	-----	8	79	-----	275	219
Other products	-----	20	-----	8	9	13	20	14	13	11	15	7	130	234
Total	1,335	1,794	1,254	1,335	1,709	1,452	1,454	1,279	1,458	1,517	1,571	1,313	17,471	16,956
DISTRICT II														
Crude oil	3,267	3,141	3,555	2,224	3,204	2,679	2,784	1,408	1,310	1,221	1,552	1,553	27,898	34,340
Unfinished oils	9	105	9	5	-----	103	3	57	5	4	12	4	316	386
Gasoline:														
Motor gasoline	1,862	1,846	2,794	2,938	2,769	2,992	2,749	2,799	3,076	3,097	3,077	3,734	33,733	25,476
Aviation gasoline	40	42	42	54	45	71	49	102	51	127	60	37	720	858
Total	1,902	1,888	2,836	2,992	2,814	2,820	3,041	2,901	3,127	3,224	3,137	3,771	34,453	26,334
Special naphthas	122	182	161	165	247	236	211	214	220	192	203	236	2,389	2,370
Kerosine	209	223	201	123	288	349	406	317	410	425	286	393	3,630	2,078
Distillate fuel oil	389	467	617	695	768	877	981	545	756	1,006	811	630	8,542	7,409
Residual fuel oil	615	686	598	825	597	439	665	452	313	502	631	603	6,926	7,424

Table 21.—Barge movements via the Mississippi river of crude oil and products from PAD District III to PAD Districts I and II, by months—Continued

(Thousand barrels)

Movements from District III to—	1968													1967 total
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total	
DISTRICT II—Continued														
Jet fuel:														
Naphtha type	-----	11	-----	-----	15	-----	13	-----	-----	9	-----	13	61	237
Kerosine type	414	490	344	366	571	387	364	454	591	1,003	661	310	5,955	5,151
Total	414	501	344	366	586	387	377	454	591	1,012	661	323	6,016	5,388
Lubricating oil	129	180	162	230	251	177	252	196	190	156	147	305	2,375	2,309
Wax	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	------	4
Asphalt and road oil	138	123	114	275	469	302	520	441	591	345	200	198	3,716	3,035
Liquefied gases	56	-----	56	112	139	159	94	14	123	59	16	115	943	1,287
Petrochemical feedstocks	55	93	162	73	172	134	171	181	107	241	199	167	1,755	2,113
Other products	29	18	83	61	76	54	67	50	47	96	66	47	694	660
Total	7,334	7,607	8,898	8,146	9,611	8,716	9,572	7,230	7,790	8,483	7,921	8,345	99,653	95,087

Table 22.—Tanker rates from U.S. gulf to destinations north of Cape Hatteras

Year	Vessels under 25,000 DWT [1]					
	Clean products (cents per gallon)			Dirty products (dollars per barrel)		
	Gasoline	Kerosine	No. 2 fuel oil	30 gravity crude oil	No. 5 fuel oil	Bunker C fuel oil
	Vessels under 25,000 DWT [1]					
1963	.92	1.01	1.06	.45	.47	.60
1964	.86	.95	1.00	.43	.46	.48
1965	.83	.91	.96	.50	.53	.56
1966	.93	1.03	1.08	.52	.55	.58
1967 [2]	1.46	1.60	1.69	.80	.85	.90
	Vessels over 25,000 DWT [1]					
1963	.85	.93	.98	.37	.39	.41
1964	.76	.84	.88	.38	.40	.43
1965	.67	.74	.78	.40	.43	.45
1966	.93	1.02	1.07	.41	.43	.46
1967 [2]	1.35	1.49	1.57	.68	.72	.77

[1] Deadweight tons.
[2] 1968 data not available.

Source: Platt's Oil Price Handbook.

Table 23.—Stocks of crude petroleum, natural gas liquids, and refined products in the United States at yearend

(Thousand barrels)

	1964	1965	1966	1967	1968
Crude petroleum:					
At refineries	63,908	59,386	62,720	72,093	78,718
Pipeline and tank farm	149,415	144,740	153,930	158,797	177,133
Producers	16,734	16,163	21,741	18,080	16,342
Total	230,057	220,289	238,391	248,970	272,193
Unfinished oils	87,014	88,609	89,213	90,201	93,399
Natural gasoline, plant condensate and isopentane	5,021	5,237	4,563	5,782	5,466
Refined products	517,143	522,209	548,938	599,158	628,514
Grand total	839,235	836,344	881,105	944,111	999,572

Table 24.—Stocks of crude petroleum in the United States by States of origin, and months, 1968

(Thousand barrels)

State of origin	Jan. 1	Jan. 31	Feb. 29	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	298	232	357	342	277	419	420	481	492	173	219	211	306
Alaska	2,222	1,297	1,706	2,270	3,039	2,931	1,694	2,648	2,570	2,595	3,104	2,365	2,551
Arizona	155	193	189	174	166	177	165	160	164	153	149	147	135
Arkansas	929	946	955	1,109	1,088	1,062	1,011	1,063	1,061	1,050	1,045	940	877
California	30,518	32,598	35,453	35,223	33,375	31,887	31,655	30,962	30,908	29,217	29,115	31,041	31,866
Colorado	3,010	2,884	3,117	3,053	3,028	3,257	3,309	3,297	2,999	3,064	3,151	3,222	3,258
Florida	256	202	278	201	229	184	233	155	256	259	279	221	224
Illinois	6,495	5,672	5,766	5,613	6,677	7,057	7,026	7,161	6,848	6,164	6,014	6,015	5,572
Indiana	324	298	264	345	421	467	460	456	373	434	468	447	545
Kansas	6,463	6,065	5,599	6,286	6,660	6,964	6,703	7,228	6,677	6,682	6,691	6,558	5,845
Kentucky	1,306	1,173	1,061	1,223	1,282	1,457	1,664	1,539	1,493	1,497	1,795	1,561	1,459
Louisiana	26,554	28,246	27,206	29,780	27,227	26,739	28,376	26,505	32,906	35,361	35,037	38,694	36,456
Michigan	772	755	680	727	779	827	849	809	821	938	915	812	679
Mississippi	2,319	2,281	2,611	2,946	2,675	2,875	2,749	3,894	4,116	4,078	5,116	4,315	5,205
Missouri	1	1	-------	1	1	1	-------	-------	-------	-------	-------	-------	-------
Montana	4,049	3,909	3,629	4,454	4,843	4,925	5,536	4,680	4,587	4,334	4,336	4,418	4,369
Nebraska	1,267	1,185	1,070	877	1,373	1,160	1,315	1,021	1,078	810	910	1,062	892
Nevada	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
New Mexico	9,656	9,270	8,993	8,910	9,848	9,977	10,052	10,257	9,394	10,105	9,780	8,906	8,997
New York	30	30	30	30	30	30	30	30	30	30	30	30	30
North Dakota	1,466	1,580	1,625	1,647	1,592	1,787	1,722	1,759	1,707	1,776	1,687	1,516	1,329
Ohio	788	704	755	811	897	847	814	931	934	956	891	778	728
Oklahoma	16,271	15,206	14,323	14,854	15,291	17,240	17,502	17,787	17,521	17,835	18,213	18,423	18,572
Pennsylvania	1,679	1,533	1,600	1,578	1,526	1,624	1,612	1,655	1,728	1,699	1,622	1,665	1,480
Texas	96,760	95,180	94,984	98,121	102,367	100,696	101,684	102,792	101,302	100,659	99,173	102,825	100,383
Utah	2,066	2,400	2,385	2,484	2,738	2,347	2,507	2,430	2,541	2,516	2,596	2,703	2,507
West Virginia	1,116	1,123	1,091	1,137	1,139	1,113	1,109	1,097	1,111	1,101	1,116	1,088	1,020
Wyoming	17,196	17,726	18,063	18,918	18,852	18,526	19,204	17,822	15,764	14,115	14,154	15,506	16,334
Total domestic crude	233,966	232,689	233,790	243,114	247,420	246,576	249,401	248,619	249,381	247,601	247,606	255,469	251,619
Foreign crude located in Districts—													
I–IV	10,384	8,048	8,093	9,711	10,155	11,089	11,391	12,283	12,262	11,414	13,381	11,184	15,169
V	4,620	4,209	3,388	4,039	4,512	4,356	4,104	4,853	4,725	3,756	5,343	4,934	5,405
Total foreign crude	15,004	12,257	11,481	13,750	14,667	15,445	15,495	17,136	16,987	15,170	18,724	16,118	20,574
Total crude stocks	248,970	244,946	245,271	256,864	262,087	262,021	264,896	265,755	266,368	262,771	266,330	271,587	272,193
Pennsylvania grade included above	3,246	3,074	3,175	3,189	3,152	3,229	3,224	3,216	3,308	3,237	3,188	3,220	2,913

Table 25.—Stocks of crude petroleum in the United States by locations and month, 1968

(Thousand barrels)

State	Jan. 1	Jan. 31	Feb. 29	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Alabama	229	279	356	295	418	382	260	652	713	773	1,022	763	1,057
Alaska	820	229	385	572	886	797	371	637	487	521	596	436	433
Arizona	474	496	491	484	472	483	476	471	476	474	472	471	468
Arkansas	1,463	1,423	1,488	1,642	1,621	1,586	1,539	1,603	1,626	1,571	1,563	1,463	1,398
California, Nevada, Oregon, Washington	36,354	37,597	39,560	40,577	40,328	38,025	36,399	37,346	37,240	34,877	36,688	37,572	39,185
Colorado	1,384	1,628	1,711	1,641	1,743	1,813	1,806	1,718	1,493	1,544	1,692	1,720	1,675
Florida, Georgia, South Carolina, Virginia	768	641	496	615	759	1,094	646	817	1,665	920	1,146	1,262	1,498
Hawaii	675	677	871	923	544	948	1,314	1,090	1,005	903	1,000	1,063	876
Illinois	13,449	12,832	14,099	14,219	15,761	15,500	16,050	15,649	15,288	14,680	15,769	16,379	17,732
Indiana	3,604	3,659	3,856	4,023	4,257	4,142	4,540	4,097	4,015	3,961	4,405	4,382	4,122
Iowa, Missouri	6,407	7,144	6,356	6,884	6,755	6,921	7,234	6,775	7,023	6,769	6,434	6,302	6,980
Kansas	9,445	9,046	8,871	9,269	9,748	10,531	9,973	10,549	9,920	9,970	10,032	10,331	9,627
Kentucky, Tennessee	3,452	3,190	3,050	3,599	3,460	3,881	3,759	3,893	3,666	3,602	3,938	3,655	4,720
Louisiana	16,157	16,223	17,466	18,664	16,794	17,060	18,052	16,362	23,033	23,380	22,337	23,655	18,027
Maryland	158	158	236	201	262	138	313	270	277	155	202	132	291
Massachusetts, Delaware, Rhode Island	1,191	655	943	836	1,003	928	1,139	1,171	1,133	837	1,020	894	850
Michigan	1,558	1,734	1,577	1,527	1,643	1,742	2,045	1,762	1,902	2,101	1,916	1,671	1,610
Minnesota, Wisconsin	1,648	1,884	1,910	1,988	1,928	2,373	2,342	2,033	1,878	2,277	2,176	1,924	1,753
Mississippi	2,539	2,584	2,400	2,661	2,917	2,678	2,659	3,415	3,736	3,869	4,223	3,432	5,248
Montana	2,414	2,198	2,254	2,680	3,135	2,890	3,078	2,769	2,754	2,770	2,671	3,056	2,770
Nebraska	1,794	1,762	1,758	1,717	1,496	1,698	1,630	1,637	1,572	1,406	1,495	1,495	1,491
New Jersey	6,866	5,797	5,331	6,292	5,595	6,119	5,398	5,928	6,346	5,554	6,239	4,941	8,228
New Mexico	3,814	3,832	3,998	3,988	4,042	4,094	3,717	3,825	3,952	4,104	4,197	4,163	3,984
New York	409	305	318	386	393	529	547	465	476	536	488	371	315
North Dakota	1,249	1,335	1,342	1,355	1,249	1,261	1,275	1,329	1,261	1,375	1,338	1,254	1,185
Ohio	6,926	6,692	6,277	6,901	7,958	7,953	6,982	6,962	6,723	6,699	6,117	6,262	6,478
Oklahoma	17,640	16,199	15,490	15,912	16,957	18,892	20,112	19,799	19,466	20,422	19,584	18,994	17,991
Pennsylvania	11,717	9,569	9,383	10,339	10,670	9,150	10,766	11,864	10,203	10,493	10,636	10,502	11,273
Texas	83,072	83,697	81,785	85,407	87,803	87,314	89,112	90,237	88,005	88,337	88,552	93,465	90,687
Utah	984	955	833	827	932	805	933	832	815	806	755	769	732
West Virginia	702	677	729	747	748	734	718	726	768	742	743	698	615
Wyoming	9,608	9,849	9,651	9,693	9,810	9,560	9,711	9,072	7,451	6,343	6,974	8,110	8,894
Total	248,970	244,946	245,271	256,864	262,087	262,021	264,896	265,755	266,368	262,771	266,330	271,587	272,193

Table 26.—Stocks of crude petroleum in the United States by classification and location, and month, 1968

(Thousand barrels)

Classification and location	Jan. 1	Jan. 31	Feb. 29	Mar. 31	Apr. 30	May 31	June 30	July 31	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
At refineries:													
Alabama	100	156	180	135	238	208	179	165	223	248	224	168	225
Alaska	87	65	103	93	87	100	108	75	80	52	78	75	54
Arkansas	320	331	323	303	286	286	257	246	235	210	220	190	171
California, Oregon, Washington	16,536	16,705	17,598	19,317	19,549	17,895	15,961	18,527	17,931	16,332	17,413	17,227	17,756
Colorado	292	324	355	341	417	395	349	390	384	304	297	346	315
Florida, Georgia, South Carolina, Virginia	608	471	337	508	533	974	415	687	1,239	778	876	1,048	1,275
Hawaii	675	677	871	923	544	948	1,314	1,090	1,005	903	1,000	1,063	876
Illinois	3,132	3,030	3,031	3,299	3,248	3,304	3,642	3,607	3,582	3,535	3,524	3,483	3,376
Indiana	1,196	1,101	1,119	1,321	1,330	1,194	1,500	1,336	1,384	1,365	1,449	1,507	1,323
Kansas	1,721	1,622	1,397	1,488	1,735	1,907	1,688	1,714	1,573	1,652	1,503	1,631	1,564
Kentucky, Tennessee	1,374	1,361	1,097	1,805	1,252	1,548	1,495	1,447	1,442	1,287	1,321	1,374	1,230
Louisiana	4,392	5,192	5,381	5,638	5,043	5,588	6,585	5,758	5,795	6,258	5,657	5,542	5,311
Maryland	158	158	236	201	262	138	313	270	277	155	202	132	291
Massachusetts, Delaware, Rhode Island	1,191	655	943	836	1,003	928	1,139	1,171	1,133	887	1,020	894	850
Michigan	858	941	840	842	981	1,028	1,086	900	948	1,097	1,037	904	683
Minnesota, Wisconsin	1,036	1,025	1,083	1,340	1,134	1,553	1,588	1,357	1,093	1,479	1,494	1,203	1,058
Mississippi	728	656	513	906	779	719	737	549	575	784	717	621	564
Missouri	279	275	325	291	261	256	284	261	285	352	369	243	256
Montana	727	645	559	655	792	638	581	569	640	689	690	843	734
Nebraska	34	28	32	30	30	22	23	29	25	30	30	35	29
New Jersey	6,866	5,797	5,331	6,292	5,595	6,119	5,398	5,928	6,346	5,554	6,239	4,941	8,228
New Mexico	183	171	188	161	311	337	278	237	187	197	189	140	180
New York	268	180	198	239	246	365	385	306	341	437	346	264	210
North Dakota	257	315	331	338	206	194	214	256	174	311	278	258	229
Ohio	1,811	2,184	1,967	2,200	2,265	2,129	2,174	2,364	2,069	2,206	2,642	2,207	2,534
Oklahoma	1,819	1,481	1,421	1,806	1,916	1,941	1,911	1,859	1,914	1,934	1,765	1,727	1,602
Pennsylvania	9,542	7,543	7,337	8,242	8,665	7,009	8,610	9,705	8,060	8,377	8,596	8,428	9,385
Texas	15,005	15,420	18,501	15,949	15,475	15,008	15,736	16,234	15,152	15,234	15,616	17,847	17,341
Utah	369	417	323	330	411	312	486	426	383	388	340	366	340
West Virginia	121	123	123	129	113	113	103	99	110	103	125	80	118
Wyoming	408	435	425	454	570	549	597	560	557	592	597	606	610
Total	72,093	69,484	67,468	76,407	75,277	73,705	75,136	78,122	75,142	73,680	75,849	75,393	78,718
Pipeline and tank-farm stocks:													
Alabama	58	57	68	56	70	64	54	420	413	457	709	521	766
Alaska	730	161	278	475	795	694	260	559	403	466	519	357	376
Arkansas	1,048	997	1,070	1,244	1,240	1,205	1,187	1,262	1,296	1,266	1,248	1,178	1,132
California, Arizona	18,334	19,394	19,703	18,964	19,026	18,224	18,434	16,854	17,278	16,795	17,241	18,479	19,825
Colorado	951	1,173	1,225	1,169	1,204	1,296	1,335	1,190	1,166	1,119	1,279	1,249	1,235
Florida	153	163	153	101	217	114	223	121	246	134	262	206	215
Illinois	9,962	9,461	10,724	10,557	12,171	11,864	12,058	11,705	11,374	10,814	11,928	12,572	14,024

Indiana	2,374	2,524	2,703	2,668	2,893	2,914	3,006	2,727	2,597	2,562	2,922	2,841	2,765
Iowa, Missouri	6,127	6,868	6,031	6,592	6,493	6,664	6,950	6,514	6,738	6,417	6,065	6,059	6,724
Kansas	7,338	7,040	7,103	7,401	7,564	8,267	7,908	8,473	7,983	7,957	8,174	8,334	7,704
Kentucky, Tennessee	2,013	1,764	1,888	1,729	2,143	2,268	2,199	2,381	2,159	2,257	2,554	2,218	3,427
Louisiana	9,341	8,674	9,591	10,521	9,425	9,226	9,381	8,322	15,121	14,854	14,449	15,641	10,525
Michigan	613	706	650	598	581	633	878	781	873	929	796	684	844
Minnesota, Wisconsin	612	859	827	648	794	820	754	676	785	798	682	721	695
Mississippi	1,494	1,602	1,550	1,405	1,793	1,622	1,573	2,524	2,810	2,740	3,179	2,455	4,348
Montana	1,264	1,115	1,237	1,567	1,878	1,830	2,055	1,761	1,688	1,650	1,572	1,798	1,587
Nebraska	1,657	1,631	1,623	1,584	1,363	1,573	1,504	1,505	1,444	1,273	1,362	1,357	1,359
New Mexico	2,108	2,114	2,310	2,297	2,212	2,283	2,016	2,162	2,234	2,388	2,397	2,395	2,292
New York	111	95	90	117	117	134	132	129	105	69	112	77	75
North Dakota	828	858	852	853	870	918	919	928	939	920	914	847	794
Ohio	5,040	4,433	4,235	4,626	5,618	5,749	4,733	4,523	4,579	4,418	3,400	3,980	3,869
Oklahoma	14,707	13,613	12,944	12,981	13,922	15,875	17,094	16,861	16,473	17,409	16,773	16,190	15,328
Pennsylvania	2,061	1,912	1,905	1,956	1,864	2,006	2,021	2,024	2,008	1,981	1,905	1,939	1,753
Texas	60,226	60,729	60,856	61,726	65,356	65,526	66,320	67,717	66,342	66,324	66,876	68,718	67,091
Utah	550	473	444	432	452	420	372	351	370	353	356	345	315
West Virginia	416	389	441	453	470	456	450	462	493	474	453	453	332
Wyoming	8,681	8,901	8,713	8,726	8,714	8,501	8,593	7,991	6,388	5,239	5,852	6,961	7,733
Total	158,797	157,706	159,214	161,446	169,245	171,146	172,409	170,923	174,305	172,063	173,979	178,575	177,133
Lease stocks	18,080	17,756	18,589	19,011	17,565	17,170	17,351	16,710	16,921	17,028	16,502	17,619	16,342
Total stocks:													
1968	248,970	244,946	245,271	256,864	262,087	262,021	264,896	265,755	266,368	262,771	266,330	271,587	272,193
1967	238,391	250,646	252,388	258,106	266,755	268,845	261,615	256,242	261,566	257,286	255,114	254,185	248,970

Table 27.—Value of crude petroleum at wells in the United States, by States

State	1967		1968	
	Total value at wells (thousand dollars)	Average value per barrel	Total value at wells (thousand dollars)	Average value per barrel
Alabama	19,500	$2.65	20,385	$2.67
Alaska	91,164	3.13	186,695	2.82
Arizona	8,188	2.80	9,606	2.85
Arkansas	56,902	2.70	53,137	2.73
California	829,133	2.31	883,644	2.35
Colorado	99,003	2.92	94,215	2.95
Illinois	179,792	3.04	173,120	3.07
Indiana	30,041	2.98	26,511	3.05
Kansas	297,600	3.00	285,405	3.02
Kentucky	45,052	2.90	41,125	2.93
Louisiana:				
Gulf Coast	2,254,162	3.13	2,414,466	3.15
Northern	165,661	3.01	156,175	3.07
Total	2,419,823	3.12	2,570,641	3.14
Michigan	39,455	2.89	38,287	2.95
Mississippi	155,726	2.72	164,396	2.80
Montana	87,543	2.50	124,488	2.57
Nebraska	36,775	2.75	36,781	2.79
New Mexico:				
Southeastern	338,408	2.94	350,430	2.97
Northwestern	29,932	2.70	28,278	2.72
Total	368,340	2.92	378,708	2.95
New York	9,026	4.58	7,093	4.63
North Dakota	65,818	2.60	66,106	2.64
Ohio	31,427	3.17	35,722	3.19
Oklahoma	676,095	2.93	668,202	2.99
Pennsylvania	19,701	4.49	18,698	4.49
South Dakota	502	2.38	401	2.15
Texas:				
Gulf Coast	705,718	3.27	737,066	3.31
East Texas Field	158,860	3.06	165,041	3.11
West Texas	1,525,226	2.92	1,565,993	2.95
Panhandle	103,288	2.97	100,478	3.02
Rest of State	882,473	2.97	882,129	3.02
Total	3,375,565	3.01	3,450,707	3.04
Utah	63,221	2.63	62,826	2.67
West Virginia	14,244	4.00	13,149	3.97
Wyoming	351,685	2.58	380,589	2.64
Other States [1]	4,406	2.28	4,189	2.30
Total United States	9,375,727	2.92	9,794,826	2.94

---

[1] Florida, Missouri, Nevada, Tennessee, and Virginia.

Table 28.—Stocks of refined petroleum products in the United States at end of month

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1967												
Gasoline:												
Motor	204,521	213,200	208,780	207,148	199,415	190,539	187,225	176,645	183,190	182,916	184,430	200,055
Aviation	8,238	8,318	7,694	7,868	7,887	7,523	7,311	7,325	7,628	7,556	7,545	7,925
Total	212,759	221,518	216,474	215,016	207,302	198,062	194,536	183,970	190,818	190,472	191,975	207,980
Special naphthas	5,686	5,640	5,451	5,624	5,423	5,332	5,625	5,585	5,678	5,592	5,621	5,748
Kerosine	21,722	18,447	17,338	18,785	19,490	21,708	23,851	25,240	25,750	26,659	26,177	25,366
Distillate fuel oil	134,626	106,789	88,130	93,706	97,366	114,470	134,822	157,908	180,499	190,446	176,131	159,703
Residual fuel oil	61,662	58,254	53,960	60,036	61,640	63,480	63,988	65,674	67,965	67,960	64,145	65,597
Jet fuel:												
Naphtha type	7,264	7,731	7,772	7,532	7,225	7,926	8,052	8,308	7,430	8,194	8,327	9,037
Kerosine type	12,189	12,945	12,664	12,723	13,230	13,389	12,980	13,294	13,657	13,631	13,725	13,174
Total	19,453	20,676	20,436	20,255	20,455	21,315	21,032	21,602	21,087	21,825	22,052	22,211
Lubricants	13,144	13,743	13,421	13,536	13,628	13,429	13,853	13,806	13,573	13,997	13,822	14,774
Wax	870	877	876	883	941	941	1,005	1,002	959	977	952	1,045
Coke	7,445	7,372	7,266	7,100	6,860	6,933	7,253	7,039	7,066	7,001	6,684	6,821
Asphalt	20,351	23,036	25,405	26,809	27,073	25,022	23,709	19,034	16,760	15,645	17,166	19,939
Road oil	1,115	1,188	1,475	1,857	1,786	1,760	1,589	1,283	1,101	868	769	804
Liquefied refinery gases [1]	33,166	30,642	33,270	41,359	50,308	57,375	63,863	69,693	73,918	75,153	69,346	64,165
Petrochemical feedstocks	2,655	2,741	2,805	3,077	3,291	3,392	3,252	3,262	3,289	3,066	3,103	3,254
Miscellaneous	1,957	1,967	1,910	2,119	1,875	1,997	2,047	2,010	2,073	2,125	1,686	1,751
Unfinished oils	89,617	90,822	95,435	97,604	100,887	96,501	97,342	96,061	91,023	94,274	93,554	90,201
Total 1967	626,228	603,712	583,652	607,766	618,325	631,717	657,767	673,169	701,559	716,060	693,183	689,359
1968												
Gasoline:												
Motor	212,772	216,430	215,814	202,756	196,435	194,548	186,762	179,783	188,730	186,549	191,845	204,496
Aviation	7,641	7,755	7,585	6,732	6,617	6,402	6,380	6,339	6,345	6,660	7,024	7,030
Total	220,413	224,185	223,399	209,488	203,052	200,950	193,142	186,122	195,075	193,209	198,869	211,526
Special naphthas	5,812	5,506	5,299	5,537	5,812	5,672	5,517	5,696	5,453	5,732	5,823	5,829
Kerosine	19,250	16,712	16,360	18,583	20,912	23,040	25,689	27,188	28,036	28,936	27,094	23,480
Distillate fuel oil	119,802	96,869	93,499	101,174	115,777	139,517	168,116	191,391	205,976	211,847	204,047	173,158
Residual fuel oil	58,535	55,074	60,472	62,830	66,910	67,566	72,443	74,312	75,803	76,940	74,041	67,359
Jet fuel:												
Naphtha type	9,263	9,154	8,486	8,493	8,670	8,443	9,270	8,593	9,408	8,765	9,228	8,904
Kerosine type	13,653	13,854	14,275	14,610	16,505	15,196	15,578	15,840	15,704	16,071	15,537	15,373
Total	22,916	23,008	22,761	23,103	25,175	23,639	24,848	24,433	25,112	24,836	24,765	24,277

See footnote at end of table.

Table 28.—Stocks of refined petroleum products in the United States at end of month—Continued

(Thousand barrels)

Product	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Lubricants	15,092	15,064	14,983	14,673	14,359	14,362	13,634	13,767	13,512	13,664	13,796	14,023
Wax	1,036	1,052	1,047	1,079	1,015	1,052	1,052	1,047	989	958	927	1,001
Coke	6,709	6,487	6,518	6,088	6,095	6,297	6,299	6,407	6,597	6,163	6,200	6,195
Asphalt	22,675	25,001	26,902	27,578	27,757	26,918	22,993	19,093	17,233	15,035	17,389	20,055
Road oil	885	955	1,167	1,240	1,401	1,363	1,185	866	753	603	521	550
Liquefied refinery gases [1]	53,815	48,971	51,368	59,717	68,432	75,449	81,134	86,560	91,869	90,786	85,544	76,160
Petrochemical feedstocks	3,328	3,330	2,932	2,914	2,891	2,990	3,172	2,808	2,827	2,949	3,126	2,945
Miscellaneous	1,736	1,902	1,915	1,826	1,824	1,991	1,811	1,786	2,005	2,035	2,081	1,956
Unfinished oils	87,946	87,806	89,009	93,775	100,065	97,698	97,365	95,819	92,938	95,975	94,609	93,399
Total 1968	639,950	611,922	617,631	629,605	661,477	688,504	718,400	737,295	764,178	769,668	758,832	721,913

---

[1] Includes LRG used for petrochemical feedstocks.

Table 29.—Posted price per barrel of petroleum at wells in the United States in 1968 by grade, with date of change

	Jan. 1	Apr. 22	May 7	June 1	June 13	July 1
Pennsylvania grade:						
Bradford and Allegheny districts	4.63	No change	No change	No change	No change	No change
In southwest Pennsylvania	4.08	do	do	do	do	Do.
Corning grade	3.07	do	do	do	3.12	Do.
Western Kentucky	3.15	do	do	do	3.20	Do.
Indiana-Illinois	3.15	do	do	do	3.20	Do.
Coldwater, Michigan	2.95	do	do	do	3.00	Do.
Oklahoma-Kansas:						
34°–34.9° A.P.I	2.97	do	do	do	3.02	Do.
36°–36.9° A.P.I	3.05	do	do	do	3.10	Do.
Texas:						
Panhandle, Carson, Gray, Hutchinson and Wheeler Counties 35°–35.9° A.P.I	2.97	do	do	do	3.06	Do.
West Texas 30°–30.9° A.P.I. (sweet)	2.91	do	do	2.96	No change	Do.
South Texas Mirando 24°–24.9° A.P.I	3.20	3.25	do	No change	do	Do.
East Texas	3.15	No change	3.20	do	do	Do.
Conroe, Texas	3.35	do	No change	do	do	Do.
Texas 30°–30.9° A.P.I	3.10	do	do	do	do	Do.
Texas 20°–20.9° A.P.I	2.90	do	do	do	do	Do.
New Mexico, Lea County 30°–30.9° (sour)	2.80	do	do	do	do	Do.
Louisiana 30°–30.9° A.P.I	3.10	do	do	do	do	Do.
Caddo Pine Island 36°–36.9° A.P.I	3.04	do	do	do	do	Do.
Arkansas, Magnolia-Smackover, Limestone 31°–31.9° A.P.I	2.72	do	do	do	do	Do.
Wyoming-Montana Elk Basin 30°–30.9° A.P.I	2.68	do	do	do	do	2.73
California:						
Coalinga 32°–32.9° A.P.I	2.96	do	do	do	do	No change
Kettleman Hills 37°–37.9° A.P.I	3.21	do	do	do	do	Do.
Midway Sunset 19°–19.9° A.P.I	2.23	do	do	do	do	Do.
Wilmington 24°–24.9° A.P.I	2.58	do	do	do	do	Do.

Source: Platt's Oil Price Handbook.

Table 30.—Wholesale price index, crude petroleum

(1957–59 =100)

Month	1964	1965	1966	1967	1968
January	97.2	96.7	96.9	98.2	99.0
February	97.2	96.7	97.0	98.2	99.0
March	97.2	96.7	97.0	98.3	99.0
April	97.2	96.7	97.0	98.3	99.0
May	97.2	96.7	97.2	98.3	99.0
June	96.8	96.7	97.4	98.3	99.3
July	96.8	96.7	97.5	98.4	99.4
August	96.7	96.7	97.7	99.0	99.7
September	96.7	96.7	97.7	99.0	99.7
October	96.7	96.7	98.1	99.0	99.7
November	96.7	96.7	98.1	99.0	99.7
December	96.7	96.9	98.1	99.0	99.7
Average	96.9	96.8	97.5	98.6	99.4

Source: Bureau of Labor Statistics, U.S. Department of Labor.

Table 31.—Average monthly price of petroleum products in the United States, 1967–68

Monthly average and grade	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Average
Gasoline 92 octane (cents per gallon):														
At refineries in Oklahoma	1967	12.25	12.37	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.38	12.52	12.38
	1968	12.63	12.63	12.63	12.63	12.63	12.63	12.63	12.63	12.63	12.63	12.63	12.63	12.63
Tank wagon prices to dealers at 55 cities on first of month	1967	16.05	15.98	16.46	16.44	16.33	16.21	16.48	16.36	16.59	16.30	16.31	16.25	16.31
	1968	16.54	16.17	16.13	16.40	16.53	16.72	16.63	16.65	16.82	16.84	16.42	16.24	16.51
At service station (including all taxes)	1967	32.58	32.53	33.23	33.22	33.03	32.97	33.42	33.31	33.68	33.33	33.33	33.24	33.16
	1968	33.65	33.18	33.18	33.48	33.70	33.99	33.94	33.87	34.17	34.22	33.66	33.40	33.71
Kerosine (cents per gallon):														
No. 1 range at Chicago district	1967	10.21	10.25	10.24	10.02	10.00	10.00	10.00	10.39	10.53	10.54	10.57	10.71	10.29
	1968	10.75	10.75	10.75	10.66	10.52	10.50	10.50	10.50	10.50	10.50	10.68	10.75	10.61
No. 1 fuel oil at Oklahoma	1967	10.55	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.81	10.79
	1968	10.86	10.88	10.88	10.88	10.88	10.88	10.88	10.88	10.88	10.88	10.88	10.88	10.87
Kerosine (or No. 1 fuel oil) at New York Harbor	1967	11.44	11.60	11.60	11.60	11.51	11.51	11.78	11.80	11.80	11.80	11.80	11.80	11.67
	1968	11.80	11.80	11.80	11.95	12.20	12.20	12.20	12.08	12.20	12.20	12.00	12.00	12.00
Kerosine (or No. 1 fuel oil) at Tampa	1967	10.97	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.00	11.10	11.50	11.50	10.18
	1968	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50	11.50
Distillate and diesel fuel oil (cents per gallon):														
No. 2 fuel oil at refineries, Oklahoma	1967	9.55	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.81	9.79
	1968	9.86	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.88	9.87
No. 2 fuel oil at New York Harbor	1967	10.44	10.60	10.60	10.60	10.51	10.51	10.78	10.80	10.80	10.80	10.80	10.80	10.67
	1968	10.80	10.80	10.80	10.95	11.20	11.20	11.20	11.08	11.00	11.00	11.00	11.00	11.00
Diesel oil, shore plants, New York	1967	10.78	10.90	10.90	10.90	10.81	10.81	11.08	11.10	11.10	11.10	11.10	11.10	10.97
	1968	11.10	11.10	11.10	11.25	11.50	11.50	11.50	11.38	11.30	11.30	11.30	11.30	11.30
Diesel oil for ships (dollars per barrel):														
New York	1967	4.40	4.47	4.47	4.47	4.47	4.47	4.60	4.61	4.61	4.61	4.63	4.58	4.53
	1968	4.56	4.56	4.56	4.61	4.73	4.73	4.73	4.68	4.65	4.58	4.56	4.56	4.63
New Orleans	1967	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.31	4.39	4.27
	1968	4.39	4.29	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.26	4.27
San Pedro	1967	4.40	4.40	4.40	4.40	4.40	4.40	4.40	4.55	4.59	4.59	4.59	4.59	4.50
	1968	4.59	4.59	4.64	4.72	4.72	4.72	4.72	4.72	4.72	4.72	4.72	4.72	4.69
Residual fuel oil (dollars per barrel):														
No. 6 fuel at refineries, Oklahoma	[1] 1967	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15	2.15
No. 5 fuel oil at New York Harbor	[1] 1967	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83	2.83
Bunker "C" for ships:														
New York	1967	2.25	2.25	2.25	2.25	2.25	2.25	2.30	2.33	2.35	2.38	2.36	2.32	2.29
	1968	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28	2.28
New Orleans	1967	2.19	2.19	2.19	2.19	2.19	2.19	2.24	2.27	2.27	2.27	2.29	2.26	2.23
	1968	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22	2.22
San Pedro	1967	2.20	2.20	2.20	2.20	2.20	1.99	1.93	1.93	1.93	1.93	1.93	1.93	2.05
	1968	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.93	1.89	1.88	1.88	1.88	1.91
Lubricating oil (cents per gallon):														
Oklahoma:														
200 viscosity, No. 3 color neutral	[1] 1967	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50	21.50
150–160 viscosity 210° bright stock, 10–25 pour test	[1] 1967	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50	24.50

Pennsylvania:														
200 viscosity, No. 3 color, neutral 420–425 flash, 25 pour test	1967	28.00	28.00	28.00	28.00	28.00	28.00	29.74	30.00	30.00	30.00	30.00	30.00	28.98
	1968	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00	30.00
600 steam refined cylinder stock filterable	1967	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.00	22.50	22.04
	1968	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50	22.50
South Texas: 500 viscosity, No. 2½–3½ color, neutral	[1] 1967	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Liquid petroleum gas (propane) (cents per gallon):														
New York Harbor	1967	9.21	9.25	9.25	9.25	9.25	9.10	8.75	8.75	8.75	8.75	8.75	8.75	8.98
	1968	8.75	8.75	8.48	8.00	7.29	7.25	7.25	7.25	7.25	7.25	7.25	7.25	7.67
Oklahoma	1967	5.94	6.00	6.00	6.00	6.00	5.87	5.75	5.75	5.75	5.75	5.75	5.73	5.86
	1968	5.69	5.49	4.68	4.13	3.77	3.75	3.75	3.75	3.75	3.75	3.75	4.05	4.19
Baton Rouge	1967	6.19	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.25	6.24
	1968	6.25	6.11	5.39	4.75	4.34	4.25	4.25	4.25	4.25	4.25	4.25	4.55	4.74
Wax (cents per pound): Pennsylvania 124° to 126°, white crude scale	[1] 1967	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13	6.13

---

[1] No change in price during 1968.

Source: Platt's Oil Price Handbook.

Table 32.—Salient statistics of the major refined petroleum products in the United States

(Thousand barrels)

	1967	1968 p
Isopentane:		
Production	3,021	2,660
Stocks at plants	24	44
Used at refineries	3,005	2,640
Natural gasoline:		
Production	136,273	145,214
Stocks end of year:		
At plants	2,645	2,584
At refineries	2,077	1,860
Total stocks	4,722	4,444
Used at refineries	135,516	145,492
Plant condensate:		
Production	37,970	38,494
Stocks end of year:		
At plants	895	841
At refineries	141	137
Total stocks	1,036	978
Used at refineries	37,524	38,552
Finished gasoline:		
Production:		
At refineries	1,838,522	1,933,827
At gas processing plants	7,261	6,211
Total gasoline production	1,845,783	1,940,038
Stocks end of year:		
At refineries	207,715	211,256
At plants	265	270
Total stocks	207,980	211,526
Imports	15,215	21,591
Exports	4,877	2,310
Domestic demand	1,842,686	1,955,773
Motor gasoline:		
Production:		
At refineries	1,801,448	1,902,264
At gas processing plants	7,261	6,211
Total motor gasoline production	1,808,709	1,908,475
Stocks end of year:		
At refineries	199,790	204,226
At plants	265	270
Total motor gasoline stocks	200,055	204,496
Imports	15,215	21,591
Exports	848	256
Domestic demand	1,809,782	1,925,369
Aviation gasoline:		
Production	37,074	31,563
Stocks end of year	7,925	7,030
Exports	4,029	2,054
Domestic demand	32,904	30,404
Special naphthas:		
Production:		
At refineries	26,912	27,643
At gas processing plants	51	473
Total production	26,963	28,116
Stocks end of year:		
At refineries	5,742	5,816
At plants	6	13
Total stocks	5,748	5,829
Imports	875	1,399
Exports	1,976	2,430
Domestic demand	25,203	27,004

See footnotes at end of table.

Table 32.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

	1967	1968 p
Kerosine (including range oil):		
Production:		
At refineries	99,061	100,545
At gas processing plants	1,293	1,027
Total production	100,354	101,572
Stocks end of year:		
At refineries	25,008	23,190
At plants	358	290
Total stocks	25,366	23,480
Imports	33	190
Exports	156	437
Domestic demand	100,078	103,110
Distillate fuel oil:		
Production:		
At refineries	804,429	839,373
At gas processing plants	359	1,308
Total production	804,788	840,681
Crude used directly as distillate	730	712
Stocks end of year:		
At refineries	159,674	173,093
At plants	29	65
Total stocks	159,703	173,158
Imports	18,492	36,558
Exports	4,269	1,785
Domestic demand	818,150	862,711
Residual fuel oil:		
Production	275,956	275,814
Crude used directly as residual	3,671	4,272
Stocks end of year	65,597	67,359
Imports	395,939	421,561
Exports	21,940	20,012
Domestic demand	651,885	679,873
Jet fuel:		
Production	273,229	314,928
Stocks end of year	22,211	24,277
Imports	32,391	37,492
Exports	2,021	2,176
Domestic demand	300,770	348,279
Naphtha type:		
Production:		
At refineries	109,650	121,165
At gas processing plants	44	277
Total production	109,694	121,442
Stocks end of year:		
At refineries	9,023	8,880
At plants	14	24
Total stocks	9,037	8,904
Imports	5,450	7,117
Exports	1,804	2,140
Domestic demand	111,546	126,552
Kerosine type:		
Production	163,535	193,486
Stocks end of year	13,174	15,373
Imports	26,941	30,375
Exports	217	36
Domestic demand	189,224	221,727
Lubricants:		
Production	64,870	65,684
Stocks end of year	14,774	14,023
Imports	40	33

See footnotes at end of table.

Table 32.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

	1967	1968 p
Lubricants—Continued		
Exports:		
Grease	357	297
Oil	18,338	17,921
Total exports	18,695	18,218
Domestic demand	44,123	48,250
Wax [1]		
Production	5,719	5,887
Stocks end of year	1,045	1,001
Imports	20	17
Exports	1,687	1,588
Domestic demand	3,868	4,360
Coke [1]		
Production:		
Marketable coke	42,944	45,823
Catalyst coke	47,989	49,367
Total production	90,933	95,190
Stocks end of year	6,821	6,195
Exports	16,279	19,497
Domestic demand	75,130	76,319
Asphalt [1]		
Production	127,767	135,460
Stocks end of year	19,939	20,055
Imports	6,447	6,236
Exports	459	473
Domestic demand	131,125	141,107
Road oil:		
Production	6,978	6,826
Stocks end of year	804	550
Domestic demand	7,093	7,080
Still gas for fuel: Production	140,034	149,796
Liquefied gases (including ethane and ethylene):		
Production:		
At gas processing plants (LPG)	326,618	351,262
At refineries (LRG):		
For fuel use	67,589	71,102
For chemical use	43,928	46,985
Total production at refineries	111,517	118,087
Total production	438,135	469,349
Stocks end of year:		
LPG stocks:		
At plants	58,685	71,140
At refineries	555	647
Total LPG stocks	59,240	71,787
LRG stocks:		
For fuel use	4,741	4,225
For chemical use	184	148
Total LRG stocks	4,925	4,373
Total stocks	64,165	76,160
Imports	9,885	11,647
Exports	9,262	10,608
LPG used at refineries	68,675	72,652
Domestic demand:		
LPG for fuel and chemical use	234,523	267,575
LRG for fuel use	65,978	71,618
LRG for chemical use	43,950	46,548
Total domestic demand	344,451	385,741
Ethane (including ethylene):		
Production:		
At gas processing plants	36,733	45,803
At refineries	7,028	9,446
Total production	43,761	55,249

See footnotes at end of table.

Table 32.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

	1967	1968 p
Liquefied gases—Continued		
Ethane—Continued		
Stocks end of year:		
At plants	2,115	2,212
At refineries	---------	---------
Total stocks	2,115	2,212
Domestic demand:		
Plant ethane	36,089	45,706
Refinery ethane and/or ethylene	7,028	9,446
Total domestic demand	43,117	55,152
Propane (including propylene):		
Production:		
At gas processing plants	169,767	184,409
At refineries:		
For fuel use	53,689	56,847
For chemical use	18,444	17,489
Total production at refineries	72,133	74,336
Total production	241,900	258,745
Stocks end of year:		
Plant propane stocks:		
At plants	37,064	44,523
At refineries	5	5
Total plant propane stocks	37,069	44,528
Refinery propane and/or propylene stocks:		
For fuel use	3,445	2,947
For chemical use	63	73
Total refinery propane and/or propylene stocks	3,508	3,020
Total stocks	40,577	47,548
Imports	4,190	5,627
Exports	1,782	2,542
Plant propane used at refineries	2,040	1,587
Domestic demand:		
Plant propane	154,644	178,448
Refinery propane and/or propylene:		
For fuel use	52,586	57,345
For chemical use	18,452	17,479
Total refinery propane and/or propylene domestic demand	71,038	74,824
Total domestic demand	225,682	253,272
Butane (including butylene):		
Production:		
At gas processing plants	75,492	78,903
At refineries:		
For fuel use	10,147	9,584
For chemical use	10,089	12,441
Total production at refineries	20,236	22,025
Total production	95,728	100,928
Stocks end of year:		
Plant butane stocks:		
At plants	14,057	16,141
At refineries	292	357
Total plant butane stocks	14,349	16,498
Refinery butane and/or butylene stocks:		
For fuel use	1,137	936
For chemical use	79	42
Total refinery butane and/or butylene stocks	1,216	978
Total stocks	15,565	17,476

See footnotes at end of table.

Table 32.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

	1967	1968 p
Liquefied gases—Continued		
Butane—Continued		
Imports	5,695	6,020
Exports	914	1,183
Plant butane used at refineries	35,586	41,526
Domestic demand:		
Plant butane	37,321	40,065
Refinery butane and/or butylene:		
For fuel use	9,737	9,785
For chemical use	10,101	12,478
Total refinery butane and/or butylene	19,838	22,263
Total domestic demand	57,159	62,328
Butane-propane mixture:		
Production:		
At gas processing plants	15,433	12,367
At refineries:		
For fuel use	3,753	4,671
For chemical use	7,022	6,494
Total production at refineries	10,775	11,165
Total production	26,208	23,532
Stocks end of year:		
Plant butane-propane mixture:		
At plants	413	528
At refineries	53	12
Total plant butane-propane mixture stocks	466	540
Refinery butane-propane mixture:		
For fuel use	159	342
For chemical use	---------	1
Total refinery butane-propane mixture stocks	159	343
Total stocks	625	883
Exports	6,566	6,883
Plant butane-propane mixture used at refineries	2,483	2,527
Domestic demand:		
Plant butane-propane mixture	6,469	3,356
Refinery butane-propane mixture:		
For fuel use	3,655	4,488
For chemical use	7,022	6,020
Total refinery butane-propane mixture	10,677	10,508
Total domestic demand	17,146	13,864
Isobutane:		
Production:		
At gas processing plants	29,193	29,780
At refineries	1,345	1,115
Total production	30,538	30,895
Stocks end of year:		
Plant isobutane:		
At plants	5,036	7,736
At refineries	205	273
Total plant isobutane stocks	5,241	8,009
Refinery isobutane	42	32
Total stocks	5,283	8,041
Plant isobutane used at refineries	28,566	27,012
Domestic demand: Refinery isobutane for chemical use	1,347	1,125
Petrochemical feedstocks (excluding LRG):[2]		
Production	87,428	95,422
Stocks end of year	3,254	2,945
Imports: Naphtha—400°	280	---------
Exports: Other	2,995	2,796

See footnotes at end of table.

Table 32.—Salient statistics of the major refined petroleum products in the United States—Continued

(Thousand barrels)

	1967	1968 p
Petrochemical feedstocks—Continued		
Domestic demand:		
Still gas	9,532	9,844
Naphtha—400°	50,349	55,618
Other	24,054	27,473
Total domestic demand	83,935	92,935
Miscellaneous products:		
Production:		
At refineries	14,919	15,711
At gas processing plants	1,566	3,385
Total production	16,485	19,096
Stocks end of year:		
At refineries	1,703	1,931
At plants	48	25
Total stocks	1,751	1,956
Exports	903	1,049
Domestic demand	15,995	17,842
Unfinished oils (net):		
Input	34,237	26,152
Stocks end of year	90,201	93,399
Imports	35,225	29,350
Shortage	106,592	116,691

p Preliminary.

[1] Conversion factors: 280 pounds of wax to the barrel; 5 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

[2] Produced at petroleum refineries. Data for LRG for petrochemical feedstocks are included with those for "Liquefied gases."

Note: "Stocks at refineries" include stocks at refineries and bulk terminals operated by refining and refined products pipeline companies, including pipeline fill. "Stocks at plants" include stocks at plants and terminals operated by natural gas processing companies and natural-gas liquids stocks at terminals of pipeline companies, including pipeline fill.

Table 33.—Input and output of petroleum products at refineries in the United States

(Thousand barrels)

	1964 [1]	1965	1966	1967	1968 p
INPUT					
Crude petroleum:					
Domestic	2,785,895	2,847,821	3,000,789	3,174,004	3,308,044
Foreign	437,434	453,021	446,404	408,590	466,316
Total crude petroleum	3,223,329	3,300,842	3,447,193	3,582,594	3,774,360
Unfinished oils rerun (net)	27,322	32,111	34,632	34,237	26,152
Total crude and unfinished oils rerun	3,250,651	3,332,953	3,481,825	3,616,831	3,800,512
Natural gas liquids:					
Liquefied petroleum gases	NA	67,419	68,403	68,675	72,652
Natural gasoline		129,552	133,484	138,521	148,132
Plant condensate		28,705	33,693	37,524	38,552
Total natural gas liquids	213,264	225,676	235,580	244,720	259,336
Other hydrocarbons and hydrogen [2]	29	13	30	87	[2] 3,377
OUTPUT					
Gasoline:					
Motor gasoline	1,598,186	1,645,172	1,742,456	1,801,448	1,902,264
Aviation gasoline	51,214	48,569	41,244	37,074	31,563
Total gasoline [3]	1,649,400	1,693,741	1,783,700	1,838,522	1,933,827

See footnotes at end of table.

Table 33.—Input and output of petroleum products at refineries in the United States—Continued

(Thousand barrels)

	1964 [1]	1965	1966	1967	1968 p
Special naphthas [3]	25,878	28,734	29,634	26,912	27,643
Kerosine [3]	93,474	93,149	100,849	99,061	100,545
Distillate fuel oil [3]	742,046	765,071	784,717	804,429	839,373
Residual fuel oil	266,825	268,567	263,961	275,956	275,814
Jet fuel:					
Naphtha type	NA	82,416	89,473	109,650	121,165
Kerosine type		108,639	125,973	163,535	193,486
Total jet fuel [3]	182,131	191,055	215,446	273,185	314,651
Lubricants	63,668	62,925	65,407	64,870	65,684
Wax [4]	5,352	5,456	5,772	5,719	5,887
Coke [4]	84,325	86,040	88,054	90,933	95,190
Asphalt [4]	114,879	123,604	129,579	127,767	135,460
Road oil	6,371	6,565	7,247	6,978	6,826
Still gas for fuel	131,257	135,295	135,459	140,034	149,796
Liquefied refinery gas (including ethane):					
For fuel use	59,244	56,125	60,090	67,590	71,102
For chemical use	47,268	50,711	46,128	43,927	46,985
Total liquefied refinery gas	106,512	106,836	106,218	111,517	118,087
Petrochemical feedstocks:					
Still gas	7,698	8,926	10,068	9,500	9,844
Naphtha—400°	24,657	24,511	38,446	50,573	55,077
Other	25,223	24,414	25,939	27,355	30,501
Total petrochemical feedstocks	57,578	57,851	74,453	87,428	95,422
Miscellaneous products [3]	13,583	13,994	16,474	14,919	15,711
Shortage (or overage)[5]	−79,335	−80,241	−89,535	−106,592	−116,691

p Preliminary. NA Not available.

[1] New basis, comparable to 1965 data.

[2] Benzol shown for 1964–67 only. "Other hydrocarbons and hydrogen" is defined as including all hydrogen, process natural gas, tar sand bitumen, gilsonite, shale oil, and other naturally occurring hydrocarbon mixtures consumed as raw materials in the production of finished products.

[3] Production at natural gasoline plants shown as direct transfers and omitted from the input and output at the refineries.

[4] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

[5] Includes losses or gains in volume during processing.

Table 34.—Percentage yields of refined petroleum products from crude oil in the United States[1]

Finished products	1964 [2]	1965	1966	1967	1968 p
Gasoline	44.1	44.0	44.4	44.0	43.9
Special naphthas	.8	.9	.9	.8	.7
Kerosine	2.9	2.8	2.9	2.7	2.7
Distillate fuel oil	22.8	22.9	22.5	22.2	22.1
Residual fuel oil	8.2	8.1	7.6	7.7	7.2
Jet fuel	5.6	5.7	6.2	7.5	8.3
Lubricating oil	2.0	1.9	1.8	1.8	1.7
Wax	.2	.2	.2	.2	.2
Coke	2.6	2.5	2.5	2.5	2.5
Asphalt	3.5	3.7	3.8	3.5	3.6
Road oil	.2	.2	.2	.2	.1
Still gas	4.0	4.1	3.9	3.9	4.0
Liquefied gases	3.3	3.2	3.0	3.1	3.1
Petrochemical feedstocks	1.8	1.7	2.1	2.4	2.5
Other finished products	.4	.5	.5	.4	.4
Shortage	−2.4	−2.4	−2.5	−2.9	−3.0
Total	100.0	100.0	100.0	100.0	100.0

p Preliminary.

[1] Other unfinished oils added to crude in computing yields.

[2] New basis, comparable to 1965 data.

Table 35.—Input and output at refineries in the United States, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
INPUT 1967													
Crude petroleum:													
Domestic	255,130	239,192	260,742	246,025	259,873	257,899	275,874	277,278	272,054	278,822	267,711	283,404	3,174,004
Foreign	38,642	29,185	35,319	36,840	37,220	36,682	34,154	32,465	29,903	32,114	31,369	34,697	408,590
Total crude petroleum	293,772	268,377	296,061	282,865	297,093	294,581	310,028	309,743	301,957	310,936	299,080	318,101	3,582,594
Unfinished oils rerun (net)	3,734	1,468	−1,275	1,061	−63	8,009	1,547	3,624	7,705	−608	3,156	5,879	34,237
Total crude and unfinished oils rerun	297,506	269,845	294,786	283,926	297,030	302,590	311,575	313,367	309,662	310,328	302,236	323,980	3,616,831
Natural gas liquids:													
Liquefied petroleum gases	7,187	5,427	5,111	4,521	4,124	4,521	4,822	4,700	5,740	7,006	7,857	7,659	68,675
Natural gasoline	10,977	10,257	11,708	11,252	11,324	11,849	11,988	12,416	11,226	12,353	11,875	11,296	138,521
Plant condensate	3,623	3,114	2,912	2,439	3,319	3,048	3,100	3,043	2,887	3,206	3,230	3,603	37,524
Total natural gas liquids	21,787	18,798	19,731	18,212	18,767	19,418	19,910	20,159	19,853	22,565	22,962	22,558	244,720
Benzol	8	7	7	6	7	7	11	6	6	7	8	7	87
OUTPUT 1967													
Gasoline:													
Motor gasoline	150,258	132,804	142,734	139,099	147,763	151,990	155,446	156,344	155,001	155,636	151,870	162,503	1,801,448
Aviation gasoline	3,273	3,103	2,901	3,016	3,503	2,818	3,082	3,332	3,277	3,149	2,901	2,719	37,074
Total gasoline [1]	153,531	135,907	145,635	142,115	151,266	154,808	158,528	159,676	158,278	158,785	154,771	165,222	1,838,522
Special naphthas [1]	2,249	2,160	2,152	2,398	2,197	2,210	2,274	2,389	2,252	2,294	2,241	2,096	26,912
Kerosine [1]	9,992	9.058	8,380	7,042	6,788	6,391	7,513	7,381	7,541	8,495	9,976	10,504	99,061
Distillate fuel oil [1]	68,584	61,854	70,099	62,964	62,723	64,861	67,612	68,227	69,087	69,170	65,492	73,756	804,429
Residual fuel oil	25,390	23,184	24,184	22,782	21,566	21,584	21,459	21,141	20,892	21,734	24,504	27,536	275,956
Jet fuel:													
Naphtha type	7,748	7,670	8,391	8,792	8,359	9,573	9,446	9,685	10,021	10,278	10,346	9,341	109,650
Kerosine type	11,621	12,294	13,084	13,134	14,330	13,860	14,263	14,164	13,492	14,804	13,815	14,674	163,535
Total jet fuel [1]	19,369	19,964	21,475	21,926	22,689	23,433	23,709	23,849	23,513	25,082	24,161	24,015	273,185
Lubricants:													
Bright stock	491	554	520	537	571	539	602	564	530	475	502	719	6,604
Neutral	2,357	2,248	2,696	2,468	2,502	2,244	2,466	2,429	2,315	2,314	2,482	2,537	29,058
Other grades	2,629	2,246	2,243	2,414	2,632	2,568	2,357	2,465	2,311	2,714	2,276	2,353	29,208
Total lubricants	5,477	5,048	5,459	5,419	5,705	5,351	5,425	5,458	5,156	5,503	5,260	5,609	64,870
Wax:													
Microcrystalline	99	105	75	118	105	80	94	93	88	99	104	97	1,157
Fully refined	278	210	186	274	225	231	241	226	217	257	288	281	2,914
Other	93	128	164	131	168	149	143	157	127	174	108	106	1,648

See footnotes at end of table.

Table 35.—Input and output at refineries in the United States, by months—Continued

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Wax—Continued													
Total wax [2]	470	443	475	523	498	460	478	476	432	530	450	484	5,719
Coke [2]	7,684	6,704	7,615	7,099	7,727	7,675	8,024	7,699	7,644	7,613	7,417	8,032	90,933
Asphalt [2]	6,943	5,737	8,124	8,982	11,372	12,773	14,821	14,858	13,721	13,418	10,084	6,934	127,767
Road oil	297	241	457	560	565	942	1,210	1,159	651	471	236	189	6,978
Still gas for fuel	11,241	10,004	10,941	10,551	12,485	12,646	12,550	12,547	12,192	12,249	11,307	11,321	140,034
Liquefied gases (including ethane):													
LRG for fuel use	5,541	5,123	5,806	5,536	6,222	5,665	5,644	5,643	5,838	5,498	5,330	5,744	67,590
LRG for chemical use	3,867	3,265	3,969	4,049	3,766	3,785	3,474	3,235	3,653	3,392	3,455	4,017	43,927
Total liquefied gases	9,408	8,388	9,775	9,585	9,988	9,450	9,118	8,878	9,491	8,890	8,785	9,761	111,517
Petrochemical feedstocks:													
Still gas	896	690	804	705	659	643	751	843	819	931	868	891	9,500
Naphtha—400°	4,331	3,553	4,362	3,968	4,012	4,286	3,580	3,981	3,975	4,638	4,816	5,071	50,573
Other	2,208	2,104	2,400	2,141	2,378	2,234	2,372	2,381	2,495	2,237	2,254	2,151	27,355
Total petrochemical feedstocks	7,435	6,347	7,566	6,814	7,049	7,163	6,703	7,205	7,289	7,806	7,938	8,113	87,428
Miscellaneous products [1]	1,320	1,213	1,247	1,385	1,222	1,367	1,263	1,138	1,231	1,305	1,023	1,205	14,919
Processing gain	—10,089	−7,602	−9,060	−8,001	−8,536	−9,099	−8,691	−8,549	−9,849	−10,445	−8,439	−8,232	−106,592
INPUT 1968													
Crude petroleum:													
Domestic	279,642	268,151	279,536	268,027	287,427	270,038	284,115	285,153	268,029	277,183	261,387	279,356	3,308,044
Foreign	33,230	28,879	33,235	31,482	36,653	40,131	44,011	43,307	44,342	42,304	43,374	45,368	466,316
Total crude petroleum	312,872	297,030	312,771	299,509	324,080	310,169	328,126	328,460	312,371	319,487	304,761	324,724	3,774,360
Unfinished oils rerun (net)	4,242	2,481	635	−2,687	−3,823	4,896	3,759	4,010	5,584	−248	3,723	3,580	26,152
Total crude and unfinished oils rerun	317,114	299,511	313,406	296,822	320,257	315,065	331,885	332,470	317,955	319,239	308,484	328,304	3,800,512
Natural gas liquids:													
Liquefied petroleum gases	6,984	5,778	5,241	4,529	4,469	4,433	4,950	5,787	6,065	7,523	8,221	8,672	72,652
Natural gasoline	12,117	10,348	11,422	12,345	13,072	12,640	12,801	13,157	12,597	12,835	12,561	12,237	148,132
Plant condensate	3,390	3,102	3,180	3,116	3,102	3,459	3,170	3,100	3,917	2,876	3,026	3,114	38,552
Total natural gas liquids	22,491	19,228	19,843	19,990	20,643	20,532	20,921	22,044	22,579	23,234	23,808	24,023	259,336
Other hydrocarbons	86	221	286	313	270	269	326	350	380	265	304	307	3,377
OUTPUT 1968													
Gasoline:													
Motor gasoline	156,488	144,882	149,999	144,186	157,403	159,281	166,720	167,078	163,716	163,061	159,438	170,062	1,902,264
Aviation gasoline	2,332	2,165	2,873	2,353	2,785	2,534	3,126	2,736	2,978	2,987	2,405	2,289	31,563

Total gasoline [1]	158,820	147,047	152,872	146,489	160,188	161,815	169,846	169,814	166,694	166,048	161,843	172,351	1,933,827
Special naphthas [1]	2,140	2,041	2,255	2,287	2,579	2,230	2,358	2,461	2,384	2,478	2,169	2,261	27,648
Kerosine [1]	10,208	9,602	9,276	7,726	8,125	6,811	6,904	7,530	7,358	8,634	8,616	9,755	100,545
Distillate fuel oil [1]	74,258	74,377	77,212	64,976	68,684	68,990	71,624	70,398	65,958	65,878	65,914	71,104	839,378
Residual fuel oil	27,697	24,538	24,726	22,761	22,658	19,693	21,249	21,401	19,432	20,366	23,652	27,641	275,814
Jet fuel:													
Naphtha type [1]	8,760	8,672	9,512	10,866	11,201	9,541	9,837	10,252	11,035	11,981	10,261	9,247	121,165
Kerosine type	15,269	15,103	15,802	15,600	16,291	15,221	17,069	17,260	16,352	17,318	15,562	16,639	193,486
Total jet fuel	24,029	23,775	25,314	26,466	27,492	24,762	26,906	27,512	27,387	29,299	25,823	25,886	314,651
Lubricants:													
Bright stock	422	502	553	549	398	383	496	498	505	484	512	506	5,808
Neutral	2,369	2,098	2,342	2,417	2,511	2,301	2,594	2,583	2,297	2,436	2,629	2,325	28,902
Other grades	2,313	2,416	2,541	2,561	2,835	2,634	2,372	2,616	2,757	2,920	2,406	2,603	30,974
Total lubricants	5,104	5,016	5,436	5,527	5,744	5,318	5,462	5,697	5,559	5,840	5,547	5,434	65,684
Wax:													
Microcrystalline	94	100	124	93	109	87	110	102	102	109	90	89	1,209
Fully refined	183	231	246	259	231	297	237	228	208	232	255	203	2,810
Other	175	142	127	148	144	145	170	156	153	144	174	190	1,868
Total wax [2]	452	473	497	500	484	529	517	486	463	485	519	482	5,887
Coke [2]	7,676	7,486	7,921	7,419	7,861	7,805	8,178	8,461	8,134	8,112	7,883	8,254	95,190
Asphalt [2]	6,361	6,244	7,299	9,846	12,990	14,155	15,285	15,663	14,835	14,028	10,943	7,811	135,460
Road oil	222	254	452	387	681	879	1,115	1,118	796	518	218	186	6,826
Still gas for fuel	13,297	10,486	11,488	11,529	12,735	13,132	13,993	13,629	12,851	12,490	11,696	12,470	149,796
Liquefied gases (including ethane):													
LRG for fuel use	5,789	5,582	6,332	5,705	6,778	6,006	6,291	6,337	5,711	5,503	5,283	5,785	71,102
LRG for chemical use	3,857	3,623	3,910	4,023	4,172	3,959	3,771	4,157	4,063	3,779	3,643	4,028	46,985
Total liquefied gases	9,646	9,205	10,242	9,728	10,950	9,965	10,062	10,494	9,774	9,282	8,926	9,813	118,087
Petrochemical feedstocks:													
Still gas	875	786	878	792	789	774	765	846	875	864	727	873	9,844
Naphtha—400°	4,797	4,624	3,747	4,592	4,811	4,934	4,397	4,266	4,481	4,943	4,818	4,667	55,077
Other	2,340	2,256	2,527	2,303	2,769	2,535	2,741	2,865	2,437	2,899	2,229	2,600	30,501
Total petrochemical feedstocks	8,012	7,666	7,152	7,687	8,369	8,243	7,903	7,977	7,793	8,706	7,774	8,140	95,422
Miscellaneous products [1]	1,033	1,264	1,227	1,432	1,347	1,377	1,371	1,470	1,374	1,354	1,256	1,206	15,711
Processing gain	−9,264	−10,514	−9,834	−7,635	−9,717	−9,838	−9,641	−9,247	−9,878	−10,780	−10,183	−10,160	−116,691

[p] Preliminary.

[1] Production at gas processing plants shown as direct transfers and omitted from the input and output at refineries.

[2] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

Table 36.—Input and output at refineries

(Thousand

Item	PAD district 1			PAD district II				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill., etc.	Minn., Wis., etc.	Okla., Kans., etc.	Total
INPUT 1967								
Crude petroleum:								
Domestic	223,522	24,734	248,256	21,796	627,106	24,916	309,274	983,092
Foreign	194,458	19,817	214,275	------	22,147	34,766	-------	56,913
Total crude petroleum	417,980	44,551	462,531	21,796	649,253	59,682	309,274	1,040,005
Unfinished oils rerun (net)	55,649	1,459	57,108	551	−1,225	−57	−171	−902
Total crude and unfinished oils rerun	473,629	46,010	519,639	22,347	648,028	59,625	309,103	1,039,103
Natural gas liquids:								
Liquefied petroleum gases	2,007	112	2,119	107	9,613	2,114	8,776	20,610
Natural gasoline	2,193	11	2,204	8	11,823	66	11,202	23,099
Plant condensate	651	------	651	13	98	399	-------	510
Total natural gas liquids	4,851	123	4,974	128	21,534	2,579	19,978	44,219
Benzol	-------	------	-------	------	56	------	13	69
OUTPUT 1967								
Gasoline:								
Motor gasoline	214,918	17,409	232,327	11,825	345,566	30,721	179,419	567,531
Aviation gasoline	1,879	27	1,906	------	3,796	------	1,247	5,043
Total gasoline [1]	216,797	17,436	234,233	11,825	349,362	30,721	180,666	572,574
Special naphthas [1]	1,067	386	1,453	342	3,462	------	2,316	6,120
Kerosine [1]	12,184	1,087	13,271	748	18,166	2,289	4,954	26,157
Distillate fuel oil [1]	123,238	11,137	134,375	4,698	134,567	15,107	73,002	227,374
Residual fuel oil	36,272	4,669	40,941	1,788	44,222	5,435	4,750	56,195
Jet fuel:								
Naphtha type	5,425	1,435	6,860	32	8,649	1,763	8,720	19,164
Kerosine type	11,033	391	11,424	20	24,133	------	9,090	33,243
Total jet fuel [1]	16,458	1,826	18,284	52	32,782	1,763	17,810	52,407
Lubricants:								
Bright stock	454	1,233	1,687	------	637	------	1,030	1,667
Neutral	2,499	1,839	4,338	279	4,245	------	3,232	7,756
Other grades	3,543	769	4,312	------	1,398	------	1,209	2,607
Total lubricants	6,496	3,841	10,337	279	6,280	------	5,471	12,030
Wax:								
Microcrystalline	268	219	487	------	22	------	254	276
Fully refined	1,075	67	1,142	41	254	------	221	516
Other	586	163	749	18	133	------	88	239
Total wax [2]	1,929	449	2,378	59	409	------	563	1,031
Coke [2]	14,376	139	14,515	92	18,617	2,659	7,765	29,133
Asphalt [2]	26,595	1,705	28,300	1,810	28,134	2,452	12,714	45,110
Road oil	-------	709	709	------	1,896	111	1,278	3,285
Still gas for fuel	17,512	1,771	19,283	1,075	29,098	1,842	11,526	43,541
Liquefied gases (including ethane):								
LRG for fuel use	10,819	654	11,473	331	11,039	1,267	8,890	21,527
LRG for chemical use	3,947	------	3,947	------	2,254	------	431	2,685
Total liquefied gases	14,766	654	15,420	331	13,293	1,267	9,321	24,212
Petrochemical feedstocks:								
Still gas	1,635	------	1,635	------	1,396	------	-------	1,396
Naphtha—400°	2,642	11	2,653	------	4,106	------	2,047	6,153
Other	733	319	1,052	------	2,365	------	407	2,772
Total petrochemical feedstocks	5,010	330	5,340	------	7,867	------	2,454	10,321
Miscellaneous products [1]	1,617	181	1,798	6	1,019	111	1,802	2,938
Processing gain (−) or loss (+)	−15,837	−187	−16,024	−630	−19,556	−1,553	−7,298	−29,037

See footnotes at end of table.

in the United States, by districts

barrels)

PAD district III						PAD district IV	PAD district V	United States
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland etc.	N. Mex.	Total	Other Rocky Mt.	West Coast	
127,650	833,245	401,460	49,201	12,438	1,423,994	118,895	399,767	3,174,004
----------	----------	619	----------	----------	619	6,511	130,272	408,590
127,650	833,245	402,079	49,201	12,438	1,424,613	125,406	530,039	3,582,594
−374	−24,911	−7,113	422	59	−31,917	−360	10,308	34,237
127,276	808,334	394,966	49,623	12,497	1,392,696	125,046	540,347	3,616,831
7,993	18,799	7,725	1,092	438	36,047	2,580	7,319	68,675
15,708	60,009	17,400	992	691	94,800	1,892	16,526	138,521
37	28,996	2,907	3,497	----------	35,437	320	606	37,524
23,738	107,804	28,032	5,581	1,129	166,284	4,792	24,451	244,720
15	----------	----------	----------	----------	15	3	----------	87
80,820	401,830	188,269	24,004	7,554	702,477	63,192	235,921	1,801,448
3,500	9,307	9,098	----------	----------	21,905	791	7,429	37,074
84,320	411,137	197,367	24,004	7,554	724,382	63,983	243,350	1,838,522
1,083	13,471	589	769	6	15,918	613	2,808	26,912
1,585	37,015	16,433	1,797	161	56,991	1,987	655	99,061
21,052	214,853	92,901	11,538	2,210	342,554	28,000	72,126	804,429
4,440	40,052	14,773	1,770	423	61,458	10,832	106,530	275,956
9,659	27,620	13,441	1,564	1,390	53,674	4,279	25,673	109,650
7,808	33,276	34,937	313	----------	76,334	2,539	39,995	163,535
17,467	60,896	48,378	1,877	1,390	130,008	6,818	65,668	273,185
----------	1,955	721	----------	----------	2,676	33	541	6,604
----------	8,647	5,851	494	----------	14,992	280	1,692	29,058
156	17,306	1,093	1,502	----------	20,057	64	2,168	29,208
156	27,908	7,665	1,996	----------	37,725	377	4,401	64,870
76	216	91	----------	----------	383	11	----------	1,157
----------	564	335	----------	----------	899	66	291	2,914
----------	374	82	----------	----------	456	22	182	1,648
76	1,154	508	----------	----------	1,738	99	473	5,719
2,253	16,735	9,365	2,007	190	30,550	3,066	13,669	90,933
5,846	8,197	8,548	6,017	794	29,402	7,337	17,618	127,767
53	42	----------	----------	----------	95	1,437	1,452	6,978
4,549	27,362	11,250	2,112	498	45,771	4,504	26,935	140,034
3,394	11,475	7,223	1,466	282	23,840	2,249	8,501	67,590
454	23,730	8,322	230	----------	32,736	----------	4,559	43,927
3,848	35,205	15,545	1,696	282	56,576	2,249	13,060	111,517
----------	5,799	----------	----------	----------	5,799	----------	670	9,500
1,429	32,814	1,600	611	19	36,473	----------	5,294	50,573
2,511	9,285	10,249	285	140	22,470	336	725	27,355
3,940	47,898	11,849	896	159	64,742	336	6,689	87,428
1,138	3,881	1,131	10	----------	6,160	522	3,501	14,919
−777	−29,668	−13,304	−1,285	−41	−45,075	−2,319	−14,137	−106,592

Table 36.—Input and output at refineries

(Thousand

Item	PAD district 1			PAD district II				
	East Coast	Appalachian No. 1	Total	Appalachian No. 2	Ind., Ill., etc.	Minn., Wis., etc.	Okla., Kans., etc.	Total
INPUT 1968 p								
Crude petroleum:								
Domestic	193,388	24,942	218,330	20,873	634,359	25,242	324,009	1,004,483
Foreign	237,376	21,370	258,746	834	35,193	42,308	59	78,394
Total crude petroleum	430,764	46,312	477,076	21,707	669,552	67,550	324,068	1,082,877
Unfinished oils rerun (net)	42,388	1,406	43,794	506	−1,625	79	−806	−1,846
Total crude and unfinished oils rerun	473,152	47,718	520,870	22,213	667,927	67,629	323,262	1,081,031
Natural gas liquids:								
Liquefied petroleum gases	2,031	53	2,084	106	9,342	2,671	8,773	20,892
Natural gasoline	2,385	8	2,393	15	12,305	258	11,113	23,691
Plant condensate	956	21	977	------	183	436	------	619
Total natural gas liquids	5,372	82	5,454	121	21,830	3,365	19,886	45,202
Other hydrocarbons	------	------	------	------	------	------	140	140
OUTPUT 1968 p								
Gasoline:								
Motor gasoline	213,140	18,134	231,274	11,732	360,036	37,119	186,046	594,933
Aviation gasoline	1,238	10	1,248	------	2,703	------	830	3,533
Total gasoline [1]	214,378	18,144	232,522	11,732	362,739	37,119	186,876	598,466
Special naphthas [1]	1,044	354	1,398	397	3,651	------	1,801	5,849
Kerosine [1]	11,669	1,327	12,996	809	17,691	2,638	4,976	26,114
Distillate fuel oil [1]	120,821	11,759	132,580	4,528	135,746	16,780	76,681	233,735
Residual fuel oil	36,129	4,700	40,829	1,807	42,563	5,930	5,750	56,050
Jet fuel:								
Naphtha type	7,078	838	7,916	6	10,213	978	8,661	19,858
Kerosine type	11,418	526	11,944	29	27,658	165	11,402	39,254
Total jet fuel [1]	18,496	1,364	19,860	35	37,871	1,143	20,063	59,112
Lubricants:								
Bright stock	501	1,266	1,767	------	613	------	854	1,467
Neutral	2,233	1,845	4,078	250	4,092	------	3,434	7,776
Other grades	3,715	760	4,475	------	1,218	------	1,364	2,582
Total lubricants	6,449	3,871	10,320	250	5,923	------	5,652	11,825
Wax:								
Microcrystalline	298	233	531	------	37	------	249	286
Fully refined	1,042	41	1,083	30	242	------	263	535
Other	666	231	897	23	134	------	63	220
Total wax [2]	2,006	505	2,511	53	413	------	575	1,041
Coke [2]	12,766	147	12,913	88	18,531	2,901	8,441	29,961
Asphalt [2]	27,478	1,760	29,238	1,823	31,105	2,674	13,697	49,299
Road oil	------	621	621	------	1,276	212	932	2,420
Still gas for fuel	18,442	1,811	20,253	954	30,161	2,188	12,204	45,507
Liquefied gases (incl. ethane):								
LRG for fuel use	11,307	868	12,175	339	10,342	1,241	9,330	21,252
LRG for chemical use	4,314	38	4,352	------	2,047	------	744	2,791
Total liquefied gases	15,621	906	16,527	339	12,389	1,241	10,074	24,043
Petrochemical feedstocks:								
Still gas	1,505	------	1,505	------	1,370	146	21	1,537
Naphtha—400°	3,318	------	3,318	------	4,113	------	1,861	5,974
Other	1,152	464	1,616	------	2,376	------	609	2,985
Total petrochemical feedstocks	5,975	464	6,439	------	7,859	146	2,491	10,496
Miscellaneous products [1]	1,597	109	1,706	8	1,427	122	1,232	2,789
Processing gain (−) or loss (+)	−14,347	−42	−14,389	−489	−19,588	−2,100	−8,157	−30,334

---

p Preliminary.

[1] Production at gas processing plants shown as direct transfers and omitted from the input and output at the refineries.

[2] Conversion factors: 280 pounds of wax to the barrel; 5.0 barrels of coke to the short ton; 5.5 barrels of asphalt to the short ton.

in the United States, by districts—Continued

barrels)

PAD district III						PAD district IV	PAD district V	
Texas Inland	Texas Gulf	La. Gulf	Ark., La., Inland etc.	N. Mex.	Total	Other Rocky Mt.	West Coast	United States
135,372	861,995	444,472	51,123	13,411	1,506,373	124,008	454,850	3,308,044
----------	----------	748	----------	----------	748	9,867	118,561	466,316
135,372	861,995	445,220	51,123	13,411	1,507,121	133,875	573,411	3,774,360
−510	−17,412	−7,407	405	−22	−24,946	−295	9,445	26,152
134,862	844,583	437,813	51,528	13,389	1,482,175	133,580	582,856	3,800,512
8,091	19,202	9,940	1,138	539	38,910	2,944	7,822	72,652
14,381	68,115	19,551	1,076	542	103,665	2,189	16,194	148,132
56	30,831	1,967	3,101	----------	35,955	350	651	38,552
22,528	118,148	31,458	5,315	1,081	178,530	5,483	24,667	259,336
3	221	560	----------	----------	784	166	2,287	3,377
84,035	414,435	212,266	24,016	8,030	742,782	68,612	264,663	1,902,264
2,596	10,296	5,888	----------	----------	18,780	616	7,386	31,563
86,631	424,731	218,154	24,016	8,030	761,562	69,228	272,049	1,933,827
980	14,427	568	859	----------	16,834	144	3,418	27,643
1,504	38,716	17,137	1,637	122	59,116	1,629	690	100,545
22,840	229,489	102,053	12,258	2,351	368,991	32,138	71,929	839,373
4,562	41,336	11,453	2,282	382	60,015	10,765	108,155	275,814
10,233	31,553	14,305	1,683	1,586	59,360	3,537	30,494	121,165
9,201	33,133	46,253	69	----------	88,656	3,578	50,054	193,486
19,434	64,686	60,558	1,752	1,586	148,016	7,115	80,548	314,651
----------	1,589	590	----------	----------	2,179	45	350	5,808
----------	9,272	5,634	520	----------	15,426	257	1,365	28,902
156	17,355	1,172	1,472	----------	20,155	55	3,707	30,974
156	28,216	7,396	1,992	----------	37,760	357	5,422	65,684
80	235	66	----------	----------	381	11	----------	1,209
----------	579	306	----------	----------	885	60	247	2,810
----------	424	84	----------	----------	508	18	225	1,868
80	1,238	456	----------	----------	1,774	89	472	5,887
2,289	17,351	10,858	2,147	192	32,837	3,272	16,207	95,190
6,285	7,694	9,782	6,349	684	30,794	7,686	18,443	135,460
52	112	----------	----------	----------	164	2,033	1,588	6,826
4,883	29,914	13,770	2,335	569	51,471	4,699	27,866	149,796
3,104	13,619	8,836	1,320	287	27,166	1,971	8,538	71,102
385	25,914	9,014	185	----------	35,498	12	4,332	46,985
3,489	39,533	17,850	1,505	287	62,664	1,983	12,870	118,087
----------	5,986	----------	----------	----------	5,986	134	682	9,844
1,566	37,863	1,740	712	----------	41,881	----------	3,904	55,077
2,628	8,495	12,493	311	188	24,115	355	1,430	30,501
4,194	52,344	14,233	1,023	188	71,982	489	6,016	95,422
1,140	5,279	1,117	7	----------	7,543	53	3,620	15,711
−1,126	−32,114	−15,554	−1,319	+79	−50,034	−2,451	−19,483	−116,691

Table 37.—Salient statistics of motor and aviation gasoline in the United States, by months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1967													
Production:													
Gasoline produced at refineries:													
Motor gasoline	150,258	132,804	142,734	139,099	147,763	151,990	155,446	156,344	155,001	155,636	151,870	162,503	1,801,448
Aviation gasoline	3,273	3,103	2,901	3,016	3,503	2,818	3,082	3,332	3,277	3,149	2,901	2,719	37,074
Motor gasoline produced at natural-gas processing plants	765	547	595	555	609	607	609	611	590	625	557	591	7,261
Total gasoline production	154,296	136,454	146,230	142,670	151,875	155,415	159,137	160,287	158,868	159,410	155,328	165,813	1,845,783
Daily average	4,977	4,873	4,717	4,756	4,899	5,180	5,133	5,171	5,296	5,142	5,178	5,349	5,057
Stocks, end of period:													
Stocks at refineries:													
Motor gasoline	204,198	212,869	208,458	206,835	199,054	190,237	186,969	176,382	182,891	182,597	184,131	199,790	199,790
Aviation gasoline	8,238	8,318	7,694	7,868	7,887	7,523	7,311	7,325	7,628	7,556	7,545	7,925	7,925
Motor gasoline stocks at natural-gas processing plants	323	331	322	313	361	302	256	263	299	319	299	265	265
Total stocks	212,759	221,518	216,474	215,016	207,302	198,062	194,536	183,970	190,818	190,472	191,975	207,980	207,980
Imports: Motor gasoline	1,472	1,623	1,202	1,891	1,818	1,063	771	823	1,244	1,129	1,101	1,078	15,215
Exports:													
Motor gasoline	25	22	10	11	22	8	135	299	270	15	16	8	841
Aviation gasoline	258	382	301	338	285	182	571	332	436	279	369	315	4,048
Total exports	283	404	311	349	307	190	706	631	706	294	385	323	4,889
Domestic demand:													
Motor gasoline	134,710	126,273	148,941	143,166	157,901	162,528	160,005	168,059	150,020	157,649	151,998	148,539	1,809,789
Aviation gasoline	2,561	2,641	3,224	2,504	3,199	3,000	2,723	2,986	2,538	2,942	2,543	2,024	32,885
Total domestic demand	137,271	128,914	152,165	145,670	161,100	165,528	162,728	171,045	152,558	160,591	154,541	150,563	1,842,674
1968													
Production:													
Gasoline produced at refineries:													
Motor gasoline	156,488	144,882	149,999	144,136	157,403	159,281	166,720	167,078	163,716	163,061	159,438	170,062	1,902,264
Aviation gasoline	2,332	2,165	2,873	2,353	2,785	2,534	3,126	2,736	2,978	2,987	2,405	2,289	31,563
Motor gasoline produced at natural-gas processing plants	545	505	559	518	508	498	472	489	498	513	511	595	6,211
Total gasoline production	159,365	147,552	153,431	147,007	160,696	162,313	170,318	170,303	167,192	166,561	162,354	172,946	1,940,038
Daily average	5,141	5,088	4,949	4,900	5,184	5,410	5,494	5,494	5,573	5,373	5,412	5,579	5,301

Stocks, end of period:													
Stocks at refineries:													
Motor gasoline	212,515	216,181	215,580	202,584	196,308	194,412	186,615	179,576	188,513	186,228	191,622	204,226	204,226
Aviation gasoline	7,641	7,755	7,585	6,732	6,617	6,402	6,380	6,339	6,345	6,660	7,024	7,030	7,030
Motor gasoline at natural-gas processing plants	257	249	234	172	127	136	147	207	217	321	223	270	270
Total stocks	220,413	224,185	223,399	209,488	203,052	200,950	193,142	186,122	195,075	193,209	198,869	211,526	211,526
Imports: Motor gasoline	1,182	816	1,761	2,046	1,935	2,082	2,610	2,130	1,739	1,931	1,760	1,599	21,591
Exports:													
Motor gasoline	24	16	12	14	44	11	35	18	18	24	17	23	256
Aviation gasoline	257	69	233	238	219	121	186	126	179	217	84	125	2,054
Total exports	281	85	245	252	263	132	221	144	197	241	101	148	2,310
Domestic demand:													
Motor gasoline	145,474	142,529	152,923	159,744	166,123	163,737	177,553	176,658	156,988	167,662	156,396	159,582	1,925,369
Aviation gasoline	2,359	1,982	2,810	2,968	2,681	2,628	2,962	2,651	2,793	2,455	1,957	2,158	30,404
Total domestic demand	147,833	144,511	155,733	162,712	168,804	166,365	180,515	179,309	159,781	170,117	158,353	161,740	1,955,773

Table 38.—Production of gasoline at refineries and gas processing plants in the United States in 1968,p by districts and months

(Thousand barrels)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Motor gasoline at refineries:													
East Coast	16,976	16,024	16,692	15,333	17,790	18,121	19,130	19,090	18,679	17,358	17,919	20,028	213,140
Appalachian No. 1	1,651	1,378	1,430	1,212	1,376	1,209	1,588	1,736	1,687	1,650	1,493	1,724	18,134
Appalachian No. 2	1,036	990	923	1,008	1,051	985	955	940	954	964	881	1,045	11,732
Indiana, Illinois, Kentucky etc	30,662	28,563	28,531	26,886	28,298	29,210	32,097	31,763	31,304	30,286	30,964	32,472	360,036
Minnesota, Wisconsin, etc	2,866	2,786	3,002	2,919	2,311	2,900	3,231	3,323	3,270	3,256	3,615	3,640	37,119
Oklahoma, Kansas, etc	15,588	14,994	15,161	15,109	15,092	15,066	15,648	16,189	15,458	16,089	15,039	16,613	186,046
Texas Inland	7,215	6,530	6,939	6,423	6,799	6,878	7,464	7,489	6,656	7,171	6,978	7,493	84,035
Texas Gulf Coast	34,050	30,924	32,530	32,569	34,930	35,744	35,429	36,702	35,233	35,702	33,799	36,773	414,435
Louisiana Gulf Coast	16,972	15,163	16,452	16,540	19,218	18,480	18,901	18,555	18,214	18,636	16,832	18,303	212,266
Arkansas, Louisiana Inland, etc	1,929	1,893	1,690	1,930	2,119	2,022	2,109	2,041	1,918	2,137	2,069	2,159	24,016
New Mexico	625	604	648	523	593	672	691	732	703	724	764	751	8,030
Rocky Mountain	5,653	5,482	5,446	4,989	5,343	5,440	6,023	6,342	6,094	5,944	5,690	6,166	68,612
West Coast	21,265	19,551	20,505	19,695	22,483	22,554	23,454	22,176	23,546	23,144	23,395	22,895	264,663
Total	156,488	144,882	149,999	144,136	157,403	159,281	166,720	167,078	163,716	163,061	159,438	170,062	1,902,264
Aviation gasoline at refineries:													
East Coast	96	2	140	100	212	36	97	112	65	114	96	168	1,238
Appalachian No. 1	-------	10	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	10
Appalachian No. 2	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Indiana, Illinois, Kentucky, etc	300	122	289	108	244	227	255	274	312	240	142	190	2,703
Minnesota, Wisconsin, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Oklahoma, Kansas, etc	100	57	75	55	71	82	88	70	68	86	39	39	830
Texas Inland	159	254	223	113	185	222	184	178	281	274	271	252	2,596
Texas Gulf Coast	545	660	971	741	824	738	1,223	1,125	1,085	889	851	644	10,296
Louisiana Gulf Coast	378	478	407	623	540	528	487	345	540	672	460	430	5,888
Arkansas, Louisiana Inland, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
New Mexico	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Rocky Mountain	61	51	62	55	61	55	68	63	21	42	48	29	616
West Coast	693	531	706	558	648	646	724	569	606	670	498	537	7,386
Total	2,332	2,165	2,873	2,353	2,785	2,534	3,126	2,736	2,978	2,987	2,405	2,289	31,563
Motor gasoline produced at gas-processing plants:													
East Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Appalachian No. 1	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Appalachian No. 2	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Indiana, Illinois, Kentucky, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Minnesota, Wisconsin, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	---------
Oklahoma, Kansas, etc	1	1	2	-------	3	-------	3	-------	1	4	3	1	19
Texas Inland	89	77	85	79	77	74	83	73	78	73	74	167	1,029
Texas Gulf Coast	28	25	25	24	27	19	23	14	27	27	26	15	280
Louisiana Gulf Coast	212	171	195	185	168	169	176	178	169	181	170	174	2,148
Arkansas, Louisiana Inland, etc	215	231	252	230	233	236	187	224	223	228	238	238	2,735

New Mexico	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Rocky Mountain	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
West Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Total	545	505	559	518	508	498	472	489	498	513	511	595	6,211
Grand total:													
1968	159,365	147,552	153,431	147,007	160,696	162,313	170,318	170,303	167,192	166,561	162,354	172,946	1,940,038
1967	154,296	136,454	146,230	142,670	151,875	155,415	159,137	160,287	158,868	159,410	155,328	165,813	1,845,783

---

p Preliminary.

Table 39.—Consumption, production, and distribution of motor gasoline in 1968,[1] by PAD districts

(Million barrels)

	PAD districts					
	I	II	III	IV	V	Total
Consumption [2]	665.3	671.4	247.4	55.8	283.3	1,923.2
Supply:						
Production [3]	231.3	594.9	749.0	68.6	264.7	1,908.5
Imports	20.4	.2	-------	-------	1.0	21.6
Received from other districts:						
From I	-------	30.1	-------	-------	-------	---------
From II	16.0	-------	19.6	-------	-------	---------
From III	434.1	80.0	-------	3.7	17.1	---------
From IV	-------	5.9	-------	-------	13.2	---------
From V	.2	-------	-------	4.4	-------	---------
Total receipts	450.3	116.0	19.6	8.1	30.3	---------
Total supply	702.0	711.1	768.6	76.7	296.0	1,930.1
Stock change	−.8	+4.9	−3.0	+.3	+3.0	+4.4
Shipped to other districts	30.1	35.6	534.9	19.1	4.6	---------
Exports	-------	-------	.1	-------	.1	.2
Domestic demand	672.7	670.6	236.6	57.3	288.3	1,925.5
Difference between consumption and demand	−7.4	+.8	+10.8	−1.5	−5.0	−2.3

---

[1] Apparent distribution of motor gasoline by districts is based on pipeline, tidewater, and river shipments compiled by the Bureau of Mines, and estimate of annual interdistrict railroad shipments is based on data compiled by the Bureau of Transport Economics, Interstate Commerce Commission, and records compiled by the San Francisco office of the Bureau of Mines. An estimate of shipments moving from PAD district II by way of the Great Lakes and the Ohio River to PAD district I was computed from 1966 data compiled by the U.S. Army Corps of Engineers.

[2] Compiled from data supplied by the American Petroleum Institute.

[3] Includes motor gasoline produced at natural-gas processing plants.

Table 40.—Production (refinery output) and consumption of gasoline (excluding naphtha) in the United States, by States

(Thousand barrels)

	1966		1967		1968 [p]	
	Production	Consumption [1]	Production	Consumption [1]	Production	Consumption [1]
Alabama	(2)	31,138	(2)	32,179	(2)	34,006
Alaska	---------	1,967	---------	2,020	---------	2,235
Arizona	---------	16,202	---------	16,720	---------	18,088
Arkansas	13,067	19,057	13,128	19,796	13,325	20,935
California	[3] 236,897	185,251	[3] 243,350	189,963	[3] 272,049	201,477
Colorado	6,533	20,363	6,821	21,702	6,998	22,944
Connecticut	---------	24,062	---------	24,844	---------	26,408
Delaware	(4)	5,518	(4)	5,752	(4)	5,776
District of Columbia	---------	5,518	---------	5,467	---------	5,575
Florida	---------	58,625	---------	61,803	---------	67,320
Georgia	---------	42,268	---------	44,621	---------	48,285
Hawaii	(3)	4,792	(3)	4,820	(3)	5,005
Idaho	---------	7,986	---------	8,340	---------	8,617
Illinois	129,538	91,999	129,482	94,642	136,576	99,696
Indiana	85,371	51,471	85,879	52,622	87,559	55,676
Iowa	---------	33,092	---------	34,292	---------	35,143
Kansas	[7] 89,140	27,198	[7] 92,215	27,699	[7] 95,898	29,114
Kentucky	[6] 19,592	27,777	[6] 22,641	29,295	[6] 22,348	30,953
Louisiana	174,369	29,899	201,780	31,277	222,477	33,027
Maine	---------	9,540	---------	9,768	---------	10,316
Maryland	---------	29,363	---------	30,745	---------	32,945
Massachusetts	---------	41,540	---------	42,639	---------	45,156
Michigan	27,782	83,649	25,664	85,379	26,478	91,128
Minnesota	17,210	38,103	17,578	38,910	22,481	41,094
Mississippi	[2] 5,615	20,255	[2] 6,463	21,192	[2] 6,368	22,417
Missouri	(7)	48,230	(7)	49,594	(7)	51,939
Montana	17,014	9,350	18,757	9,458	21,210	9,560
Nebraska	(7)	17,629	(7)	18,190	(7)	18,962
Nevada	---------	6,089	---------	6,184	---------	6,726
New Hampshire	---------	6,298	---------	6,621	---------	7,218
New Jersey	82,070	57,963	81,670	59,139	79,970	62,572
New Mexico	7,620	11,507	7,554	11,589	8,030	12,297
New York	10,431	127,346	10,881	133,159	11,831	138,401
North Carolina	---------	46,290	---------	48,818	---------	51,502
North Dakota	[8] 13,600	8,419	[8] 13,143	8,401	[8] 14,638	8,698
Ohio	94,199	92,140	97,521	94,649	101,510	100,086
Oklahoma	85,705	31,723	88,451	32,227	90,978	33,786
Oregon	---------	20,975	---------	21,668	---------	22,766
Pennsylvania	[4] 130,098	89,436	[4] 132,950	92,508	[4] 131,756	97,040
Rhode Island	---------	6,886	---------	7,099	---------	7,596
South Carolina	---------	22,846	---------	23,890	---------	25,687
South Dakota	---------	9,362	---------	9,481	---------	9,822
Tennessee	(6)	35,955	(6)	37,845	(6)	39,200
Texas	489,937	137,446	495,457	139,126	511,362	153,876
Utah	20,493	11,159	20,429	11,717	20,590	12,810
Vermont	---------	4,048	---------	4,336	---------	4,555
Virginia	(5)	40,063	(5)	42,102	(5)	45,011
Washington	(3)	30,105	(3)	31,821	(3)	33,836
West Virginia	[5] 7,821	13,658	[5] 8,732	14,171	[5] 8,965	15,120
Wisconsin	(8)	38,556	(8)	39,532	(8)	42,017
Wyoming	19,598	4,997	17,976	5,106	20,435	5,514
Total	1,783,700	1,835,109	1,838,522	1,894,918	1,933,827	2,009,928

[p] Preliminary.
[1] American Petroleum Institute.
[2] Alabama included with Mississippi.
[3] Washington and Hawaii included with California.
[4] Delaware included with Pennsylvania.
[5] Virginia included with West Virginia.
[6] Tennessee included with Kentucky.
[7] Nebraska and Missouri included with Kansas.
[8] Wisconsin included with North Dakota.

Table 41.—Stocks of gasoline in the United States, in 1968, by districts and months

(Thousand barrels)

	Jan. 31	Feb. 29	Mar. 31	Apr. 30	May 31	June 30	July 30	Aug. 31	Sept. 30	Oct. 31	Nov. 30	Dec. 31
Motor gasoline: [1]												
East Coast	51,241	48,550	49,364	48,931	51,252	51,627	50,447	47,895	51,530	52,173	52,468	51,389
Appalachian No. 1	5,613	5,448	5,448	4,882	5,266	5,098	4,988	4,670	5,269	5,194	5,073	5,586
Appalachian No. 2	3,617	3,536	3,554	3,150	3,288	3,037	3,105	2,915	3,244	3,346	3,239	3,409
Indiana, Illinois, Kentucky, etc	35,024	37,868	38,350	35,232	31,676	31,027	30,862	29,257	31,870	29,286	30,744	34,366
Minnesota, Wisconsin, North Dakota and South Dakota	7,402	7,521	7,995	7,916	7,559	7,875	6,717	5,804	6,611	6,258	6,996	7,846
Oklahoma, Kansas, etc	18,718	20,287	20,667	20,257	19,044	17,436	16,063	15,338	16,014	16,606	16,813	18,089
Texas Inland	9,398	9,322	10,297	9,495	8,670	7,454	6,787	6,399	6,738	6,360	7,059	7,783
Texas Gulf	28,473	28,572	26,446	22,516	20,308	22,465	20,674	21,518	20,803	21,499	22,440	25,565
Louisiana Gulf Coast	16,238	14,822	13,883	13,327	13,063	12,456	12,561	13,196	12,689	12,706	11,201	12,546
Arkansas, Louisiana Inland, etc	7,660	9,638	9,005	8,751	6,700	6,989	6,074	6,964	7,484	5,916	6,310	6,662
New Mexico	828	832	1,015	821	801	797	840	783	801	840	976	959
Rocky Mountain	6,556	7,626	8,021	7,571	7,341	6,553	5,646	4,929	5,223	5,238	5,872	6,847
West Coast	21,747	22,159	21,535	19,735	21,340	22,098	21,901	19,908	20,237	20,806	22,431	23,179
Total	212,515	216,181	215,580	202,584	196,308	194,412	186,615	179,576	188,513	186,228	191,622	204,226
Aviation gasoline: [1]												
East Coast	1,134	1,059	918	917	1,009	886	884	923	892	848	839	898
Appalachian No. 1	75	95	108	103	101	70	75	81	77	70	86	78
Appalachian No. 2	9	6	2	2	4	2	2	2	1	1	1	2
Indiana, Illinois, Kentucky, etc	1,097	1,081	1,074	894	825	894	810	780	944	890	871	937
Minnesota, Wisconsin, North Dakota and South Dakota	159	153	130	162	176	145	140	179	160	196	225	198
Oklahoma, Kansas, etc	360	340	375	287	289	249	252	251	278	234	264	230
Texas Inland	609	588	590	572	481	525	468	385	382	387	469	532
Texas Gulf	1,411	1,408	1,479	1,199	1,082	1,030	1,118	1,345	994	1,032	1,246	1,303
Louisiana Gulf Coast	1,172	1,336	1,133	939	1,075	1,011	1,019	865	967	1,824	1,204	1,338
Arkansas, Louisiana Inland, etc	36	-------	37	4	-------	-------	40	-------	25	-------	-------	-------
New Mexico	25	24	10	15	19	10	3	8	3	13	4	2
Rocky Mountain	140	145	143	132	138	124	125	114	85	89	111	97
West Coast	1,414	1,520	1,586	1,506	1,418	1,456	1,444	1,406	1,537	1,576	1,704	1,415
Total	7,641	7,755	7,585	6,732	6,617	6,402	6,380	6,339	6,345	6,660	7,024	7,030
Motor gasoline stocks at gas-processing plants:												
East Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Appalachian No. 1	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Appalachian No. 2	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Indiana, Illinois, Kentucky, etc	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Minnesota, Wisconsin, North Dakota and South Dakota	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Oklahoma, Kansas, etc	4	5	6	4	7	5	4	6	8	5	4	4
Texas Inland	36	25	36	28	21	30	21	23	31	37	37	35

Texas Gulf	21	17	15	14	13	11	15	11	20	24	28	12
Louisiana Gulf Coast	91	72	86	71	56	48	57	65	48	108	37	102
Arkansas, Louisiana Inland, etc	105	130	91	55	30	42	50	102	115	147	117	117
New Mexico	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Rocky Mountain	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
West Coast	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------
Total	257	249	234	172	127	136	147	207	217	321	223	270
Total gasoline stocks:												
1968	220,413	224,185	223,399	209,488	208,052	200,950	193,142	186,122	195,075	193,209	198,869	211,526
1967	212,759	221,518	216,474	215,016	207,302	198,062	194,536	183,970	190,818	190,472	191,975	207,980

[1] Includes stocks of gasoline at refineries, bulk terminals and pipelines.

Table 42.—Shipments of aviation fuels

(Thousand barrels)

Product and use	Shipments to PAD districts I	II	III	IV	V	U.S. total
1967						
Aviation gasoline:						
For commercial use:						
Airlines	2,509	2,286	602	254	267	5,918
Factory	81	48	64	2	19	214
General aviation	1,993	2,337	1,550	361	2,733	8,974
Total	4,583	4,671	2,216	617	3,019	15,106
For military use	5,593	3,005	4,636	488	6,015	19,737
Jet fuel:						
For commercial use:						
Airlines	64,196	34,403	12,821	4,897	51,508	167,825
Factory	1,172	479	180	--------	697	2,528
General aviation	1,703	1,692	465	81	1,548	5,489
Total	67,071	36,574	13,466	4,978	53,753	175,842
For military use:						
JP-4	30,867	20,889	20,586	3,759	[1] 36,959	113,060
JP-5	5,260	191	3,128	--------	7,343	15,922
Other	104	75	165	--------	591	935
Total	36,231	21,155	23,879	3,759	44,893	129,917
1968						
Aviation gasoline:						
For commercial use:						
Airlines	1,455	1,073	326	130	668	3,652
Factory	110	19	31	2	18	180
General aviation	2,184	2,649	1,718	379	1,668	8,598
Total	3,749	3,741	2,075	511	2,354	12,430
For military use	4,163	2,947	5,878	405	4,854	18,247
Jet fuel:						
For commercial use:						
Airlines	76,192	40,468	15,705	5,945	57,340	195,650
Factory	1,648	524	267	--------	811	3,250
General aviation	2,114	1,898	959	318	1,175	6,464
Total	79,954	42,890	16,931	6,263	59,326	205,364
For military use:						
JP-4	[2] 34,683	18,873	26,429	3,170	[2] 42,833	125,988
JP-5	5,568	79	3,370	--------	7,788	16,805
Other	124	117	404	--------	672	1,317
Total	40,375	19,069	30,203	3,170	51,293	144,110

[1] Excludes 783,000 barrels imported directly by the military.

[2] Excludes 244,000 barrels imported directly by the military in PAD District I and 1,396,000 barrels in PAD District V.

Definitions of terms used in this table:

1. Aviation gasoline—Any fuel in the gasoline boiling range for use in a piston-type aviation engine.
2. Jet fuel—Any fuel for use in an aviation turbine engine.
3. Airline—Sales to U.S. certificated air carriers, including air freight carriers, international air carriers (if delivery is made in the U.S.), and to such other air carriers as supplemental or nonschedule carriers, air taxi, etc.
4. Factory—Direct sales to airframe and engine manufacturers.
5. General aviation—Primarily sales to distributors and airport dealers.
6. Military—Sales to Defense Fuel Supply Center and to other military agencies of the Government.

Table 43.—Salient statistics of kerosine in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

Month and refining districts	1967							1968 p						
	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks (end of period)	Domestic demand	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks (end of period)	Domestic demand
Month:														
January	9,992	3.4	104	-------	13	21,722	13,574	10,208	3.2	72	-------	38	19,250	[1] 16,257
February	9,058	3.4	83	-------	19	18,447	12,397	9,602	3.2	70	-------	34	16,712	12,176
March	8,380	2.8	94	-------	10	17,338	9,573	9,276	3.0	84	-------	29	16,360	9,683
April	7,042	2.5	87	33	13	18,785	5,702	7,726	2.6	73	1	15	18,583	5,562
May	6,788	2.3	109	-------	21	19,490	6,171	8,125	2.5	73	-------	15	20,912	5,854
June	6,391	2.1	108	-------	7	21,708	4,274	6,811	2.2	90	31	12	23,040	4,792
July	7,513	2.4	102	-------	11	23,851	5,461	6,904	2.1	59	-------	15	25,689	4,299
August	7,381	2.4	120	-------	11	25,240	6,101	7,530	2.3	104	30	12	27,188	6,153
September	7,541	2.4	122	-------	12	25,750	7,141	7,358	2.3	107	-------	15	28,036	6,602
October	8,495	2.7	120	-------	2	26,659	7,704	8,634	2.7	101	-------	16	28,936	7,819
November	9,976	3.3	115	-------	29	26,177	10,544	8,616	2.8	97	-------	64	27,094	10,491
December	10,504	3.2	129	-------	8	25,366	11,436	9,755	3.0	97	128	172	23,480	13,422
Total	99,061	2.7	1,293	33	156	25,366	100,078	100,545	2.7	1,027	190	437	23,480	[1] 103,110
Refining districts:														
East Coast	12,184	2.6	-------	33	47	10,126		11,669	2.5	-------	190	30	9,808	
Appalachian No. 1	1,087	2.4	-------			629		1,327	2.8	-------			728	
Appalachian No. 2	748	3.4	-------			302		809	3.7	-------			470	
Indiana, Illinois, Kentucky, etc.	18,166	2.8	-------	-------	10	4,745		17,691	2.7	-------	-------	260	4,205	
Minnesota, Wisconsin, etc.	2,289	3.9	-------			865		2,638	3.9	-------			974	
Oklahoma, Kansas, etc.	4,954	1.6	-------			1,125	NA	4,976	1.6	-------			1,385	NA
Texas Inland	1,585	1.2	208			355		1,504	1.1	291			282	
Texas Gulf Coast	37,015	4.6	58			3,017		38,716	4.6	-------			2,585	
Louisiana Gulf Coast	16,433	4.1	406	-------	57	2,240		17,187	3.9	125	-------	95	1,623	
Arkansas, Louisiana Inland etc.	1,797	3.6	579			1,285		1,637	3.2	571			911	
New Mexico	161	1.3	42			63		122	.9	40			58	
Rocky Mountain	1,987	1.6	-------	-------	-------	464		1,629	1.2	-------	-------	-------	289	
West Coast	655	.1	-------	-------	42	150		690	.1	-------	-------	52	162	
Total	99,061	2.7	1,293	33	156	25,366	100,078	100,545	2.7	1,027	190	437	23,480	[1] 103,110

p Preliminary. NA Not available.

[1] Domestic demand calculated using January 1, 1968, total stocks of 25,265,000 barrels.

Table 44.—Salient statistics of distillate fuel oil in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

Month and refining districts	1967								1968 P							
	Production at refineries	Yield (percent)	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Total stocks, end of period	Domestic demand	Production at refineries	Yield (per-(cent	Production at gas processing plants	Crude used directly as distillate [1]	Imports	Exports	Total stocks (end of period)	Domestic demand
Month:																
January	68,584	23.0	58	63	1,148	117	134,626	[2] 93,222	74,258	23.4	24	58	3,745	184	119,802	117,802
February	61,854	22.9	34	57	895	316	106,789	90,361	74,377	24.8	89	57	3,512	296	96,869	100,672
March	70,099	23.8	36	66	2,696	306	88,130	91,250	77,212	24.6	101	65	4,794	154	93,499	85,388
April	62,964	22.2	35	58	1,378	423	93,706	58,436	64,976	21.9	97	61	2,837	156	101,174	60,140
May	62,723	21.1	26	61	1,302	102	97,366	60,350	68,684	21.4	95	54	2,024	169	115,777	56,085
June	64,861	21.4	25	60	1,327	338	114,470	48,831	68,990	21.9	109	58	2,509	61	139,517	47,865
July	67,612	21.7	26	63	893	428	134,822	47,814	71,624	21.6	76	61	2,946	106	168,116	46,002
August	68,227	21.8	25	64	1,054	220	157,908	46,064	70,398	21.2	138	62	2,226	81	191,391	49,468
September	69,087	22.3	22	60	1,155	421	180,499	47,312	65,958	20.7	139	60	2,586	353	205,976	53,805
October	69,170	22.3	25	61	1,681	642	190,446	60,348	65,878	20.6	152	62	2,217	72	211,847	62,366
November	65,492	21.7	22	60	1,435	521	176,131	80,803	65,914	21.4	147	55	2,511	56	204,047	76,371
December	73,756	22.8	25	57	3,528	435	159,703	93,359	71,104	21.6	141	59	4,651	97	173,158	106,747
Total	804,429	22.2	359	730	18,492	4,269	159,703	[2] 818,150	839,373	22.1	1,308	712	36,558	1,785	173,158	862,711
Refining districts:																
East Coast	123,238	26.0	-----	-----	16,851	37	66,787		120,821	25.5	-----	-----	33,912	114	69,389	
Appalachian No. 1	11,137	24.2	-----				3,171		11,759	24.7	-----				3,538	
Appalachian No. 2	4,698	21.0	-----				2,055		4,528	20.3	-----				2,261	
Indiana, Illinois, Kentucky, etc	134,567	20.7	-----	451	224	276	22,145		135,746	20.3	-----	442	360	174	26,133	
Minnesota, Wisconsin, etc	15,107	25.3	-----				8,229		16,780	24.8	-----				8,133	
Oklahoma, Kansas, etc	73,002	23.6	-----				12,972	NA	76,681	23.7	-----				11,403	NA
Texas Inland	21,052	16.6	173				2,190		22,840	17.0	195				1,751	
Texas Gulf Coast	214,853	26.6	25				18,345		229,489	27.2	51				23,276	
Louisiana Gulf Coast	92,901	23.6	41	206	891	2,181	6,231		102,053	23.3	196	200	1,290	708	8,444	
Arkansas, Louisiana Inland, etc	11,538	23.3	120				2,355		12,258	23.8	866				5,000	
New Mexico	2,210	17.7	-----				224		2,351	17.5	-----				200	
Rocky Mountain	28,000	22.4	-----	73	------	5	2,602		32,138	24.0	-----	70	------	4	2,677	
West Coast	72,126	13.3	-----	-----	526	1,770	12,397		71,929	12.3	-----	-----	996	785	10,953	
Total	804,429	22.2	359	730	18,492	4,269	159,703	[2] 818,150	839,373	22.1	1,308	712	36,558	1,785	173,158	862,711

P Preliminary. NA Not available.

[1] Figures represent crude oil used as fuel on pipelines, which is considered part of the demand for distillate.

[2] Domestic demand calculated using revised total stocks of 158,112,000 barrels as of December 31, 1966.

Table 45.—Salient statistics of residual fuel oil in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

Month and refining districts	1967							1968 p						
	Production	Yield (percent)	Crude used directly as residual[1]	Imports	Exports	Stocks (end of period)	Domestic demand	Production	Yield (percent)	Crude used directly as residual[1]	Imports	Exports	Stocks (end of period)	Domestic demand
Month:														
January	25,390	8.5	256	44,340	1,578	61,662	[2] 70,602	27,697	8.7	340	50,932	1,628	58,535	84,403
February	23,184	8.6	231	38,327	1,384	58,254	63,766	24,538	8.2	329	42,287	1,472	55,074	69,143
March	24.184	8.2	260	41,108	1,608	53,960	68,238	24,726	7.9	344	46,446	2,245	60,472	63,873
April	22,782	8.0	350	36,542	1,281	60,036	52,317	22,761	7.7	476	32,657	2,084	62,830	51,452
May	21,566	7.3	233	30,839	1,658	61,640	49,376	22,658	7.1	341	27,801	2,236	66,910	44,484
June	21,584	7.1	295	26,587	1,560	63,480	45,066	19,693	6.2	343	30,949	2,175	67,566	48,154
July	21,459	6.9	373	23,128	1,956	63,988	42,496	21,249	6.4	373	30,473	1,211	72,443	46,007
August	21,141	6.8	329	26,472	2,556	65,674	43,700	21,401	6.4	320	26,121	1,900	74,312	44,073
September	20,892	6.7	322	24,208	2,835	67,965	40,296	19,432	6.1	360	31,278	1,271	75,803	48,308
October	21,734	7.0	359	35,406	1,857	67,960	55,647	20,366	6.4	355	32,575	1,260	76,940	50,899
November	24,504	8.1	335	31,038	2,464	64,145	57,228	23,652	7.7	341	31,782	1,043	74,041	57,631
December	27,536	8.5	328	37,944	1,203	65,597	63,153	27,641	8.4	350	38,260	1,487	67,359	71,446
Total	275,956	7.7	3,671	395,939	21,940	65,597	[2] 651,885	275,814	7.2	4,272	421,561	20,012	67,359	679,873
Refining districts:														
East Coast	36,272	7.7	------	383,260	319	18,647	NA	36,129	7.7	------	405,967	1,544	23,597	NA
Appalachian No. 1	4,669	10.1				468		4,700	9.8				274	
Appalachian No. 2	1,788	8.0				132		1,807	8.2				103	
Indiana, Illinois, Kentucky, etc.	44,222	6.9	564	587	503	6,574		42,563	6.4	577	573	709	6,293	
Minnesota, Wisconsin, etc.	5,435	9.1				1,038		5,930	8.7				1,051	
Oklahoma, Kansas, etc.	4,750	1.5				1,062		5,750	1.8				876	
Texas Inland	4,440	3.5	1,768	7,475	4,911	2,185		4,562	3.3	1,784	8,271	3,641	2,143	
Texas Gulf Coast	40,052	5.0				4,898		41,336	4.9				3,569	
Louisiana Gulf Coast	14,773	3.7				1,728		11,453	2.6				1,225	
Arkansas, Louisiana Inland, etc.	1,770	3.6				78		2,282	4.4				131	
New Mexico	423	3.4				35		382	2.9				5	
Rocky Mountain	10,832	8.6	243	60	1	812		10,765	8.1	252	54	1	752	
West Coast	106,530	19.8	1,096	4,557	16,206	27,940		108,155	18.6	1,659	6,696	14,117	27,340	
Total	275,956	7.7	3,671	395,939	21,940	65,597	[2] 651,885	275,814	7.2	4,272	421,561	20,012	67,359	679,873

p Preliminary. NA Not available.

[1] Represents crude oil used as fuel on leases and for general industrial purposes.

[2] Domestic demand calculated using revised total stocks of 63,856,000 barrels as of December 31, 1966.

Table 46.—Salient statistics of jet fuel in the United States, by months and refining districts

(Thousand barrels)

Month and refining districts	Production: Naphtha type [1]	Production: Kerosine type	Production: Total	Imports: Naphtha type	Imports: Kerosine type	Imports: Total	Exports: Naphtha type	Exports: Kerosine type	Exports: Total	Total stocks end of period: Naphtha type	Total stocks end of period: Kerosine type	Total stocks end of period: Total	Domestic demand: Naphtha type	Domestic demand: Kerosine type	Domestic demand: Total
1967															
Month:															
January	7,752	11,621	19,373	237	1,983	2,220	216	------	216	7,264	12,189	19,453	7,752	13,554	21,306
February	7,673	12,294	19,967	177	1,512	1,689	159	9	168	7,731	12,945	20,676	7,224	13,041	20,265
March	8,394	13,084	21,478	682	1,662	2,344	215	1	216	7,772	12,664	20,436	8,820	15,026	23,846
April	8,796	13,134	21,930	622	1,683	2,305	90	------	90	7,532	12,723	20,255	9,568	14,758	24,326
May	8,362	14,330	22,692	159	2,113	2,272	133	------	133	7,225	13,230	20,455	8,695	15,936	24,631
June	9,577	13,860	23,437	767	2,374	3,141	160	------	160	7,926	13,389	21,315	9,483	16,075	25,558
July	9,450	14,263	23,713	959	2,600	3,559	241	122	363	8,052	12,980	21,032	10,042	17,150	27,192
August	9,689	14,164	23,853	417	2,739	3,156	121	81	202	8,308	13,294	21,602	9,729	16,508	26,237
September	10,025	13,492	23,517	262	1,786	2,048	125	------	125	7,430	13,657	21,087	11,040	14,915	25,955
October	10,283	14,804	25,087	499	3,625	4,124	43	4	47	8,194	13,631	21,825	9,975	18,451	28,426
November	10,349	13,815	24,164	289	2,268	2,557	149	------	149	8,327	13,725	22,052	10,356	15,989	26,345
December	9,344	14,674	24,018	380	2,596	2,976	152	------	152	9,037	13,174	22,211	8,862	17,821	26,683
Total	109,694	163,535	273,229	5,450	26,941	32,391	1,804	217	2,021	9,037	13,174	22,211	111,546	189,224	300,770
Refining districts:															
East Coast	5,425	11,033	16,458	1,500	17,240	18,740				689	2,423	3,112			
Appalachian No. 1	1,435	391	1,826							84	249	333			
Appalachian No. 2	32	20	52							46	138	184			
Indiana, Illinois, Kentucky, etc	8,649	24,133	32,782	-------	538	538				722	2,430	3,152			
Minnesota, Wisconsin, etc	1,763	-------	1,763							146	382	528			
Oklahoma, Kansas, etc	8,720	9,090	17,810				150	197	347	891	805	1,696	NA	NA	NA
Texas Inland	9,659	7,808	17,467							600	662	1,262			
Texas Gulf	27,620	33,276	60,896							2,245	1,210	3,455			
Louisiana Gulf Coast	13,441	34,937	48,378	------	247	247				908	997	1,905			
Arkansas, Louisiana Inland, etc	1,608	313	1,921							513	352	865			
New Mexico	1,390	-------	1,390							213	39	252			
Rocky Mountain	4,279	2,539	6,818	------	------	------				302	159	461			
West Coast	25,673	39,995	65,668	3,950	8,916	12,866	1,654	20	1,674	1,678	3,328	5,006			
Total	109,694	163,535	273,229	5,450	26,941	32,391	1,804	217	2,021	9,037	13,174	22,211	111,546	189,224	300,770
1968 p															
Month:															
January	8,800	15,269	24,069	476	2,261	2,737	143	------	143	9,263	13,653	22,916	8,907	[3] 17,152	[3] 26,059
February	8,709	15,103	23,812	689	2,965	3,654	180	------	180	9,154	13,854	23,008	9,327	17,867	27,194
March	9,541	15,802	25,343	641	1,903	2,544	268	------	268	8,486	14,275	22,761	10,582	17,284	27,866

April	10,896	15,600	26,496	613	2,595	3,208	151	------	151	8,493	14,610	23,103	11,351	17,860	29,211
May	11,241	16,291	27,532	494	2,272	2,766	194	------	194	8,670	16,505	25,175	11,364	16,668	28,032
June	9,581	15,221	24,802	1,076	1,893	2,969	154	------	154	8,443	15,196	23,639	10,730	18,423	29,153
July	9,876	17,069	26,945	480	3,139	3,619	161	------	161	9,270	15,578	24,848	9,368	19,826	29,194
August	10,257	17,260	27,517	378	3,044	3,422	239	36	275	8,593	15,840	23,433	11,073	20,006	31,079
September	11,039	16,352	27,391	464	2,636	3,100	148	------	148	9,408	15,704	25,112	10,540	19,124	29,664
October	11,985	17,318	29,303	437	3,002	3,439	105	------	105	8,765	16,071	24,836	12,960	19,953	32,913
November	10,265	15,562	25,827	473	2,334	2,807	172	------	172	9,228	15,537	24,765	10,103	18,430	28,533
December	9,252	16,639	25,891	896	2,331	3,227	225	------	225	8,904	15,373	24,277	10,247	19,134	29,381
Total	121,442	193,486	314,928	7,117	30,375	37,492	2,140	36	2,176	[2]8,904	15,373	24,277	126,552	[3]221,727	[3]348,279
Refining districts:															
East Coast	7,078	11,418	18,496	1,714	19,787	21,501				560	2,822	3,382			
Appalachian No. 1	838	526	1,364							58	218	276			
Appalachian No. 2	6	29	35							37	52	89			
Indiana, Illinois, Kentucky, etc	10,213	27,658	37,871							748	2,988	3,736			
Minnesota, Wisconsin, etc	978	165	1,143	------	164	164	320	35	355	178	482	660			
Oklahoma, Kansas, etc	8,661	11,402	20,063							871	878	1,749	NA	NA	NA
Texas Inland	10,233	9,201	19,434							627	709	1,336			
Texas Gulf	31,553	33,133	64,686							2,124	1,309	3,433			
Louisiana Gulf Coast	14,536	46,253	60,789	------	392	392				749	1,009	1,758			
Arkansas, Louisiana Inland, etc	1,729	69	1,798							391	459	850			
New Mexico	1,586	------	1,586							228	31	259			
Rocky Mountain	3,537	3,578	7,115	------	------	------				387	297	684			
West Coast	30,494	50,054	80,548	5,403	10,032	15,435	1,820	1	1,821	1,946	4,119	6,065			
Total	121,442	193,486	314,928	7,117	30,375	37,492	2,140	36	2,176	[2]8,904	15,373	24,277	126,552	[3]221,727	[3]348,279

---

[p] Preliminary. NA Not available.

[1] Includes naphtha-type jet fuel produced at natural gas-processing plants: 1967, Arkansas, Louisiana Inland, etc.—44; 1968, Louisiana Gulf, 231; Arkansas, Louisiana Inland, etc.—46.

[2] Includes naphtha-type jet fuel sorted at natural gas processing plants: 1967, Arkansas, Louisiana Inland, etc.—14; 1968, Texas Inland—1; Arkansas, Louisiana Inland, etc.—23.

[3] Domestic demand for kerosine-type jet fuel calculated using January 1, 1968, total stocks of 22,312,000 barrels.

Table 47.—Salient statistics of lubricants in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

Month and refining districts	Production				Yield (percent)	Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Bright stock	Neutral	Other grades	Total				Bright stock	Neutral	Other grades	Total	
1967												
Month:												
January	491	2,357	2,629	5,477	1.8	3	1,274	1,503	3,616	8,025	13,144	3,744
February	554	2,248	2,246	5,048	1.9	1	1,495	1,647	3,957	8,139	13,743	2,955
March	520	2,696	2,243	5,459	1.9	2	1,936	1,448	3,817	8,156	13,421	3,847
April	537	2,468	2,414	5,419	1.9	3	1,755	1,566	4,088	7,882	13,536	3,552
May	571	2,502	2,632	5,705	1.9	3	1,802	1,519	4,159	7,950	13,628	3,814
June	539	2,244	2,568	5,351	1.8	4	1,358	1,544	3,960	7,925	13,429	4,196
July	602	2,466	2,357	5,425	1.7	4	1,445	1,698	4,186	7,969	13,853	3,560
August	564	2,429	2,465	5,458	1.8	4	1,494	1,574	4,065	8,167	13,806	4,015
September	530	2,315	2,311	5,156	1.7	4	1,497	1,595	4,237	7,741	13,573	3,896
October	475	2,314	2,714	5,503	1.8	3	1,611	1,614	4,200	8,183	13,997	3,471
November	502	2,482	2,276	5,260	1.7	5	1,811	1,663	4,250	7,909	13,822	3,629
December	719	2,537	2,353	5,609	1.7	4	1,217	1,886	4,811	8,077	14,774	3,444
Total	6,604	29,058	29,208	64,870	1.8	40	18,695	1,886	4,811	8,077	14,774	44,123
Refining districts:												
East Coast	454	2,499	3,543	6,496	1.3	23	18,069	143	685	2,404	3,232	NA
Appalachian No. 1	1,233	1,839	769	3,841	8.4			215	294	292	801	
Appalachian No. 2	------	279	--------	279	1.3	14		-------	54	54	108	
Indiana, Illinois, Kentucky, etc	637	4,245	1,398	6,280	1.0			112	656	853	1,621	
Minnesota, Wisconsin, etc	------	--------	--------	--------	--------			-------	--------	43	43	
Oklahoma, Kansas, etc	1,030	3,232	1,209	5,471	1.8			160	604	181	945	
Texas Inland	------	--------	156	156	.1	1		-------	--------	42	42	
Texas Gulf Coast	1,955	8,647	17,306	27,908	3.4			506	1,393	2,685	4,584	
Louisiana Gulf Coast	721	5,851	1,093	7,665	2.0			84	714	333	1,131	
Arkansas, Louisiana Inland	------	494	1,502	1,996	4.1			-------	48	363	411	
New Mexico	------	--------	--------	--------	--------			-------	--------	5	5	
Rocky Mountain	33	280	64	377	.3	--------		11	63	41	115	
West Coast	541	1,692	2,168	4,401	.8	2	626	655	300	781	1,736	
Total	6,604	29,058	29,208	64,870	1.8	40	18,695	1,886	4,811	8,077	14,774	44,123
1968 p												
Month:												
January	422	2,369	2,313	5,104	1.6	3	1,021	1,830	5,041	8,221	15,092	3,768
February	502	2,098	2,416	5,016	1.7	3	1,255	1,925	4,922	8,217	15,064	3,792
March	553	2,342	2,541	5,436	1.7	4	1,662	1,938	4,787	8,258	14,983	3,859
April	549	2,417	2,561	5,527	1.9	2	1,546	1,932	4,538	8,203	14,673	4,293
May	398	2,511	2,835	5,744	1.8	2	1,617	1,753	4,298	8,308	14,359	4,443
June	383	2,301	2,634	5,318	1.7	2	1,624	1,661	4,315	8,386	14,362	3,698
July	496	2,594	2,372	5,462	1.6	3	1,885	1,550	4,206	7,878	13,634	4,308

August	498	2,583	2,616	5,697	1.7	3	1,508	1,460	4,423	7,884	13,767	4,059
September	505	2,297	2,757	5,559	1.7	3	1,820	1,575	4,209	7,728	13,512	3,997
October	484	2,436	2,920	5,840	1.8	3	1,303	1,411	4,189	8,064	13,664	4,388
November	512	2,629	2,406	5,547	1.8	3	1,666	1,490	4,482	7,874	13,796	3,752
December	506	2,325	2,603	5,434	1.6	2	1,311	1,620	4,286	8,117	14,023	3,898
Total	5,808	28,902	30,974	65,684	1.7	33	18,218	1,620	4,286	8,117	14,023	48,250
Refining districts:												
East Coast	501	2,233	3,715	6,449	1.4	17		172	713	2,654	3,539	
Appalachian No. 1	1,266	1,845	760	3,871	8.1			223	295	339	857	
Appalachian No. 2	------	250	--------	250	1.2			-------	38	49	87	
Indiana, Illinois, Kentucky, etc.	613	4,092	1,218	5,923	.8	14		106	558	871	1,535	
Minnesota, Wisconsin, etc.	------	--------	--------	--------	--------			------	--------	43	43	
Oklahoma, Kansas, etc.	854	3,434	1,364	5,652	1.7		17,279	145	578	214	937	
Texas Inland	------	--------	156	156	.1			------	--------	37	37	NA
Texas Gulf Coast	1,589	9,272	17,355	28,216	3.4			354	1,221	2,509	4,084	
Louisiana Gulf Coast	590	5,634	1,172	7,396	1.7	2		54	638	257	949	
Arkansas, Louisiana Inland, etc.	------	520	1,472	1,992	3.9			-------	50	378	428	
New Mexico	------	--------	--------	--------	--------			-------	--------	4	4	
Rocky Mountain	45	257	55	357	.3	--------		13	44	31	88	
West Coast	350	1,365	3,707	5,422	1.0	--------	939	553	151	731	1,435	
Total	5,808	28,902	30,974	65,684	1.7	33	18,218	1,620	4,286	8,117	14,023	48,250

ᵖ Preliminary.
NA Not available.

Table 48.—Salient statistics of liquefied gases and ethane in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

Month and refining districts	1967								1968 p							
	Refinery production	Yield percent	Production at gas processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand	Refinery production	Yield percent	Production at gas processing plants	Imports	Exports	LPG used at refineries	Total stocks, end of period	Domestic demand
Month:																
January	9,408	3.2	27,458	1,130	677	7,187	33,166	35,499	9,646	3.0	28,514	1,753	750	6,984	53,815	42,529
February	8,388	3.1	24,912	1,340	811	5,427	30,642	30,926	9,205	3.1	27,951	1,221	880	5,778	48,971	36,563
March	9,775	3.3	27,763	907	722	5,111	33,270	29,984	10,242	3.2	30,362	897	810	5,241	51,368	33,053
April	9,585	3.4	27,203	637	736	4,521	41,359	24,079	9,728	3.2	28,817	689	565	4,529	59,717	25,791
May	9,988	3.3	27,432	651	694	4,124	50,308	24,304	10,950	3.4	29,824	725	835	4,469	68,432	27,480
June	9,450	3.2	25,970	548	784	4,521	57,375	23,596	9,965	3.1	27,504	525	1,168	4,433	75,449	25,376
July	9,118	2.9	26,596	460	626	4,822	63,863	24,238	10,062	3.0	29,060	580	972	4,950	81,134	28,095
August	8,878	2.8	27,002	600	976	4,700	69,693	24,974	10,494	3.2	28,572	623	711	5,787	86,560	27,765
September	9,491	3.1	26,399	637	765	5,740	73,918	25,797	9,774	3.1	28,584	889	810	6,065	91,869	27,063
October	8,890	2.9	28,500	873	883	7,006	75,153	29,139	9,282	2.9	30,041	1,065	1,064	7,523	90,786	32,884
November	8,785	2.9	28,279	1,057	801	7,857	69,346	35,270	8,926	2.9	30,274	1,158	977	8,221	85,544	36,402
December	9,761	3.0	29,104	1,045	787	7,659	64,165	36,645	9,813	3.0	31,759	1,522	1,066	8,672	76,160	42,740
Total	111,517	3.1	326,618	9,885	9,262	68,675	64,165	344,451	118,087	2.5	351,262	11,647	10,608	72,652	76,160	385,741
Refining districts:																
East Coast	14,766	3.1		189		2,007	3,855		15,621	3.3	4,359	669		2,031	4,384	
Appalachian No. 1	654	1.4				112			906	1.9				53		
Appalachian No. 2	331	1.4				107			339	1.5				106		
Indiana, Illinois, Kentucky, etc.	13,293	2.0		5,591		9,618	18,464		12,389	1.9	58,268	5,077		9,342		
Minnesota, Wisconsin, etc.	1,267	2.2				2,114			1,241	1.9			9,554	2,671	20,247	
Oklahoma, Kansas, etc.	9,321	3.0				8,776			10,074	3.1				8,773		
Texas Inland	3,848	3.1	NA		8,313	7,993		NA	3,489	2.6				8,091		NA
Texas Gulf Coast	35,205	4.3				18,799			39,533	4.7				19,202		
Louisiana Gulf Coast	15,545	3.9		18		7,725	40,476		17,850	4.1	272,082	------		9,940	49,992	
Arkansas, Louisiana Inland, etc.	1,696	3.4				1,092			1,505	2.9				1,138		
New Mexico	282	2.3				433			287	2.2				539		
Rocky Mountain	2,249	1.8		819		2,580	315		1,983	1.5	7,964	2,199		2,944	303	
West Coast	13,060	2.4		3,268	949	7,319	1,055		12,870	1.1	8,589	3,702	1,054	7,822	1,234	
Total	111,517	3.1	326,618	9,885	9,262	68,675	64,165	344,451	118,087	2.5	351,262	11,647	10,608	72,652	76,160	385,741

p Preliminary.
NA Not available.

Table 49.—Statistical summary of petroleum asphalt and road oil

(Thousand short tons)[1]

	1964	1965	1966	1967	1968 [p]
Petroleum asphalt:					
Production	20,887	22,473	23,560	23,230	24,629
Imports (including natural)	1,075	1,145	1,110	1,172	1,134
Exports	139	71	87	77	86
Stocks (end of period)	2,588	2,941	3,147	3,625	3,646
Apparent domestic consumption	21,845	23,194	24,377	23,847	25,656
Petroleum asphalt shipments:					
Paving	17,367	18,307	19,648	18,867	20,690
Roofing	4,217	4,045	3,992	3,967	4,767
All other	2,462	2,832	2,798	2,969	2,922
Total	24,046	25,184	26,438	25,803	28,379
Road oil:					
Production	1,158	1,194	1,318	1,269	1,241
Stocks (end of period)	105	106	167	146	100
Apparent domestic consumption	1,190	1,193	1,257	1,290	1,287
Road oil shipments	1,208	1,189	1,045	1,033	1,154

[p] Preliminary.

[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 50.—Salient statistics of petroleum asphalt in the United States, by months and refining districts

(Thousand short tons)[1]

Month and refining districts	1967					1968 p				
	Production	Imports (including natural)	Exports	Stocks (end of period)	Domestic	Production	Imports (including natural)	Exports	Stocks (end of period)	Domestic demand
Month:										
January	1,262	156	7	3,700	858	1,156	77	9	4,123	727
February	1,043	16	6	4,188	565	1,135	58	9	4,546	761
March	1,477	43	12	4,619	1,077	1,327	18	4	4,891	996
April	1,633	45	7	4,874	1,416	1,790	35	8	5,014	1,694
May	2,159	62	6	4,922	2,167	2,362	62	6	5,047	2,385
June	2,322	131	4	4,549	2,822	2,574	223	9	4,894	2,940
July	2,604	133	9	4,311	2,966	2,779	138	10	4,181	3,620
August	2,701	149	5	3,460	3,696	2,848	78	7	3,471	3,628
September	2,495	140	6	3,047	3,042	2,697	149	7	3,133	3,178
October	2,440	98	7	2,844	2,734	2,551	152	6	2,734	3,097
November	1,833	148	5	3,120	1,700	1,990	80	6	3,162	1,636
December	1,261	51	3	3,625	804	1,420	64	5	3,646	994
Total	23,230	1,172	77	3,625	23,847	24,629	1,134	86	3,646	25,656
Refining districts:										
East Coast	4,836	969		963		4,996	1,000		994	
Appalachian No. 1	310			55		320			86	
Appalachian No. 2	329			93		332			101	
Illinois, Indiana, Kentucky, etc	5,115	28		649		5,656	33		611	
Minnesota, Wisconsin, etc	446			55		486			64	
Oklahoma, Kansas, etc	2,312		42	402		2,490		58	411	
Texas Inland	1,063			137	NA	1,143			111	NA
Texas Gulf Coast	1,490			185		1,399			139	
Louisiana Gulf Coast	1,554	175		159		1,779	101		215	
Arkansas, Louisiana Inland, etc	1,094			189		1,154			177	
New Mexico	144			41		124			20	
Rocky Mountain	1,334	--------		269		1,397	--------		289	
West Coast	3,203	--------	35	428		3,353	--------	28	428	
Total	23,230	1,172	77	3,625	23,847	24,629	1,134	86	3,646	25,656

p Preliminary. NA Not available.

[1] Converted from barrels to short tons (5.5 barrels = 1 short ton).

Table 51.—Salient statistics of road oil in the United States, by months and refining districts

(Short tons)[1]

Month and refining districts	1967			1968 p		
	Production	Stocks (end of period)	Domestic demand	Production	Stocks (end of period)	Domestic demand
Month:						
January	54,000	202,727	18,364	40,364	160,909	25,636
February	43,818	216,000	30,545	46,182	173,636	33,455
March	83,091	268,182	30,909	82,182	212,182	43,636
April	101,818	337,636	32,364	70,364	225,455	57,091
May	102,727	324,727	115,636	123,818	254,727	94,545
June	171,273	320,000	176,000	159,818	247,818	166,727
July	220,000	288,909	251,091	202,727	215,455	235,091
August	210,727	233,273	266,363	203,272	157,455	261,273
September	118,364	200,182	151,455	144,727	136,909	165,273
October	85,636	157,818	128,000	94,182	109,636	121,455
November	42,909	139,818	60,909	39,637	94,727	54,546
December	34,364	146,182	28,000	33,818	100,000	28,545
Total	1,268,727	146,182	1,289,636	1,241,091	100,000	1,287,273
Refining districts:						
East Coast	---------	---------	NA	---------	-------	NA
Appalachian No. 1	128,909	---------		112,909	2,363	
Appalachian No. 2	---------	---------		---------	-------	
Indiana, Illinois, Kentucky, etc	344,727	19,818		232,000	5,636	
Minnesota, Wisconsin, etc	20,182	---------		38,545	-------	
Oklahoma, Kansas, etc	232,364	47,636		169,455	22,364	
Texas Inland	9,636	---------		9,455	182	
Texas Gulf Coast	7,636	364		20,364	364	
Louisiana Gulf Coast	---------	---------		---------	-------	
Arkansas, Louisiana Inland, etc	---------	---------		---------	-------	
New Mexico	---------	---------		---------	-------	
Rocky Mountain	261,273	21,818		369,636	30,182	
West Coast	264,000	56,546		288,727	38,909	
Total	1,268,727	146,182	1,289,636	1,241,091	100,000	1,287,273

p Preliminary. NA Not available.

[1] Converted from barrels to short tons (5.5 barrels =1 short ton).

Table 52.—Salient statistics of special naphthas in the United States, by months and refining districts

(Thousand barrels unless otherwise stated)

Month and refining districts	1967								1968 p							
	Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks (end of period)	Domestic demand		Production at refineries	Yield (percent)	Production at gas-processing plants	Imports	Exports	Total stocks (end of period)	Domestic demand
Month:															
January	2,249	0,8	6	1	171	5,868	1,988	2,140	0.7	47	149	130	5,812	2,142
February	2,160	.8	3	2	179	5,640	2,032	2,041	.7	48	2	169	5,506	2,228
March	2,152	.7	7	146	152	5,451	2,342	2,255	.7	47	95	237	5,299	2,367
April	2,398	.8	8	1	168	5,624	2,061	2,287	.8	37	2	180	5,537	1,908
May	2,197	.7	4	2	167	5,423	2,237	2,579	.8	37	78	283	5,812	2,181
June	2,210	.7	4	3	158	5,332	2,150	2,230	.7	42	64	119	5,672	2,357
July	2,274	.7	5	1	110	5,625	1,877	2,358	.7	36	273	292	5,517	2,530
August	2,389	.8	3	2	169	5,585	2,265	2,461	.7	35	2	185	5,696	2,134
September	2,252	.7	4	2	146	5,678	2,019	2,384	.8	33	2	253	5,453	2,409
October	2,294	.7	5	148	197	5,592	2,336	2,478	.8	33	198	145	5,732	2,285
November	2,241	.7	3	64	123	5,621	2,156	2,169	.7	33	275	198	5,823	2,188
December	2,096	.6	4	3	236	5,748	1,740	2,261	.7	45	264	239	5,829	2,325
Total	26,912	.8	51	375	1,976	5,748	25,203	27,643	.7	473	1,399	2,430	5,829	27,004
Refining districts:															
East Coast	1,067	.3	------	356	576	1,401		1,044	.2	------	1,281	521	1,416	
Appalachian No. 1	386	.8	------			86		354	.7	------			94	
Appalachian No. 2	342	1.5	------			20		397	1.8	------			30	
Indiana, Illinois, Kentucky, etc	3,462	.6	------	19	286	989		3,651	.5	------	13	258	989	
Minnesota, Wisconsin, etc	------	------	------			89		------	------	------			60	
Oklahoma, Kansas, etc	2,316	.8	------			275		1,801	.5	41			165	
Texas Inland	1,083	.9	43			181	NA	980	.7	38			116	NA
Texas Gulf Coast	13,471	1.6	------			1,639		14,427	1.7	------			1,870	
Louisiana Gulf Coast	589	.2	2	------	992	107		568	.1	------	105	1,378	80	
Arkansas, Louisiana Inland, etc	769	1.5	6			166		859	1.7	394			173	
New Mexico	6	------	------			1		------	------	------			1	
Rocky Mountain	613	.5	------	------	------	45		144	.2	------	------	3	24	
West Coast	2,808	.5	------	------	122	749		3,418	.6	------	------	270	811	
Total	26,912	.8	51	375	1,976	5,748	25,203	27,643	.7	473	1,399	2,430	5,829	27,004

p Preliminary.
NA Not available.

Table 53.—Salient statistics on wax in the United States, by types, months, and refining districts

(Thousand barrels)[1]

Month and refining districts	1967										
	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Microcrystalline	Fully refined	Other	Total			Microcrystalline	Fully refined	Other	Total	
Month:											
January	99	278	93	470	1	145	205	394	271	870	317
February	105	210	128	443	-------	145	208	396	273	877	291
March	75	236	164	475	6	154	183	371	322	876	328
April	118	274	131	523	-------	175	167	421	295	883	341
May	105	225	168	498	-------	130	182	439	320	941	310
June	80	231	149	460	-------	137	190	440	311	941	323
July	94	241	143	478	6	128	201	465	339	1,005	292
August	93	226	157	476	-------	136	194	435	373	1,002	343
September	88	217	127	432	1	131	187	442	330	959	345
October	99	257	174	530	-------	166	181	453	343	977	346
November	104	238	108	450	6	115	192	441	319	952	366
December	97	281	106	484	-------	125	196	498	351	1,045	266
Total	1,157	2,914	1,648	5,719	20	1,687	196	498	351	1,045	3,868
Refining districts:											
East Coast	268	1,075	586	1,929	20		38	143	57	238	
Appalachian No. 1	219	67	163	449			28	49	60	137	
Appalachian No. 2	—	41	18	59			------	6	-------	6	
Indiana, Illinois, Kentucky, etc	22	254	133	409	------		1	33	91	125	
Minnesota, Wisconsin, etc	-------	-------	-------	-------			------	-------	-------	-------	
Oklahoma, Kansas, etc	254	221	88	563		1,573	45	21	7	73	
Texas Inland	76	-------	-------	76			31	-------	-------	31	NA
Texas Gulf Coast	216	564	374	1,154			25	62	115	202	
Louisiana Gulf Coast	91	335	82	508	------		21	101	5	127	
Arkansas, Louisiana Inland, etc	-------	-------	-------	-------			------	-------	-------	-------	
New Mexico	-------	-------	-------	-------			------	-------	-------	-------	
Rocky Mountain	11	66	22	99	-------		7	20	16	43	
West Coast	-------	291	182	473	-------	114	------	63	-------	63	
Total	1,157	2,914	1,648	5,719	20	1,687	196	498	351	1,045	3,868

See footnotes at end of table.

Table 53.—Salient statistics on wax in the United States, by types, months, and refining districts—Continued

(Thousand barrels) [1]

Month and refining districts	1968 p										
	Production				Imports (all types)	Exports (all types)	Stocks, end of period				Domestic demand (all types)
	Micro-crystal-line	Fully refined	Other	Total			Micro-crystal-line	Fully refined	Other	Total	
Month:											
January	94	183	175	452	-------	108	192	430	414	1,036	353
February	100	231	142	473	-------	105	189	425	438	1,052	352
March	124	246	127	497	1	125	199	432	416	1,047	378
April	93	259	148	500	6	128	190	499	390	1,079	346
May	109	231	144	484	1	146	181	446	388	1,015	403
June	87	297	145	529	-------	153	176	499	377	1,052	339
July	110	237	170	517	1	159	193	456	403	1,052	359
August	102	228	156	486	2	132	186	457	404	1,047	361
September	102	208	153	463	6	149	171	421	397	989	378
October	109	232	144	485	-------	107	166	402	390	958	409
November	90	255	174	519	-------	153	165	376	386	927	397
December	89	203	190	482	-------	123	170	341	490	1,001	285
Total	1,209	2,810	1,868	5,887	17	1,588	170	341	490	1,001	4,360
Refining districts:											
East Coast	298	1,042	666	2,006	14	1,480	30	100	79	209	NA
Appalachian No. 1	233	41	231	505			25	31	154	210	
Appalachian No. 2	-------	30	23	53	-------		-------	5	-------	5	
Indiana, Illinois, Kentucky, etc	87	242	134	413			14	17	129	160	
Minnesota, Wisconsin, etc	-------	-------	-------	-------			-------	-------	-------	-------	
Oklahoma, Kansas, etc	249	263	63	575	3		48	22	9	79	
Texas Inland	80	-------	-------	80			18	-------	-------	18	
Texas Gulf Coast	285	579	424	1,238			17	46	87	150	
Louisiana Gulf Coast	66	306	84	456			13	49	17	79	
Arkansas, Louisiana Inland, etc	-------	-------	-------	-------			-------	-------	-------	-------	
New Mexico	-------	-------	-------	-------			-------	-------	-------	-------	
Rocky Mountain	11	60	18	89	-------		5	33	15	53	
West Coast	-------	247	225	472	-------	108	-------	38	-------	38	
Total	1,209	2,810	1,868	5,887	17	1,588	170	341	490	1,001	4,360

p Preliminary. NA Not available.

[1] Conversion factor: 280 pounds to the barrel.

Table 54.—Salient statistics of petroleum coke in the United States, by months and refining districts[1]

(Thousand barrels unless otherwise stated)

Month and refining districts	1967							1968 p						
	Marketable	Production catalyst	Total	Yield (percent)	Exports	Stocks (end of period)	Domestic demand	Marketable	Production catalyst	Total	Yield (percent)	Exports	Stocks (end of period)	Domestic demand
Month:														
January	3,505	4,179	7,684	2.6	830	7,445	6,706	3,766	3,910	7,676	2.4	1,096	6,709	6,692
February	3,087	3,617	6,704	2.5	1,550	7,372	5,227	3,542	3,944	7,486	2.5	1,565	6,487	6,143
March	3,693	3,922	7,615	2.6	560	7,266	7,161	3,772	4,149	7,921	2.5	1,464	6,518	6,426
April	3,235	3,864	7,099	2.5	1,554	7,100	5,711	3,648	3,771	7,419	2.5	1,414	6,088	6,435
May	3,735	3,992	7,727	2.6	1,590	6,860	6,377	3,850	4,011	7,861	2.5	1,827	6,095	6,027
June	3,674	4,001	7,675	2.5	1,716	6,933	5,886	3,687	4,118	7,805	2.5	1,407	6,297	6,196
July	3,923	4,101	8,024	2.6	1,484	7,253	6,220	3,824	4,354	8,178	2.5	1,673	6,299	6,503
August	3,581	4,118	7,699	2.5	1,263	7,039	6,650	3,937	4,524	8,461	2.6	1,709	6,407	6,644
September	3,522	4,122	7,644	2.5	1,558	7,066	6,059	3,918	4,216	8,134	2.6	1,671	6,597	6,273
October	3,627	3,986	7,613	2.4	1,490	7,001	6,188	3,987	4,125	8,112	2.5	1,750	6,163	6,796
November	3,503	3,914	7,417	2.5	1,448	6,684	6,286	3,995	3,888	7,883	2.5	1,802	6,200	6,044
December	3,859	4,173	8,032	2.5	1,236	6,821	6,659	3,897	4,357	8,254	2.5	2,119	6,195	6,140
Total	42,944	47,989	90,933	2.5	16,279	6,821	75,130	45,823	49,367	95,190	2.5	19,497	6,195	76,319
Refining districts:														
East Coast	6,225	8,151	14,376	3.1	9,222	1,112	NA	5,512	7,254	12,766	2.7	9,177	687	NA
Appalachian No. 1	------	139	139	.3		------		3	144	147	.4		------	
Appalachian No. 2	------	92	92	.5		------		------	88	88	.4		------	
Indiana, Illinois, Kentucky, etc.	8,637	9,980	18,617	2.8		734		8,578	9,953	18,531	2.8		847	
Minnesota, Wisconsin, etc.	1,988	671	2,659	4.5		123		2,101	800	2,901	4.3		61	
Oklahoma, Kansas, etc.	4,039	3,726	7,765	2.5		258		4,043	4,398	8,441	2.6		62	
Texas Inland	492	1,761	2,253	1.7		2		471	1,818	2,289	1.7		1	
Texas Gulf Coast	3,798	12,937	16,735	2.1		23		3,968	13,383	17,351	2.1		16	
Louisiana Gulf Coast	4,101	5,264	9,365	2.4		139		4,977	5,881	10,858	2.4		465	
Arkansas, Louisiana Inland, etc.	1,240	767	2,007	4.0		328		1,395	752	2,147	4.1		251	
New Mexico	------	190	190	1.5		------		------	192	192	1.5		------	
Rocky Mountain	1,173	1,893	3,066	2.5		1,447		1,234	2,038	3,272	2.4		1,567	
West Coast	11,251	2,418	13,669	2.5	7,057	2,660		13,541	2,666	16,207	2.8	10,320	2,238	
Total	42,944	47,989	90,933	2.5	16,279	6,821	75,130	45,823	49,367	95,190	2.5	19,497	6,195	76,319

p Preliminary. NA Not available.

[1] Conversion factor: 5.0 barrels to the short ton.

Table 55.—Production of miscellaneous finished oils in the United States in 1968, by districts and classes

(Thousand barrels)

District	Absorption	Petrolatum	Specialty oils	Petrochemicals	Other products	Total
East Coast	-------	-------	1,062	283	252	1,597
Appalachian No. 1	3	52	29	-------	25	109
Appalachian No. 2	-------	-------	8	-------	-------	8
Indiana, Illinois, Kentucky, etc	5	16	174	661	571	1,427
Minnesota, Wisconsin, etc	-------	-------	-------	122	-------	122
Oklahoma, Kansas, etc	81	453	565	45	164	1,308
Texas Inland	219	-------	226	884	30	1,359
Texas Gulf	65	501	619	3,848	311	5,344
Louisiana Gulf	2,807	78	-------	891	148	3,924
Arkansas, Louisiana Inland	211	-------	-------	7	-------	218
Rocky Mountain, New Mexico	7	-------	-------	17	36	60
West Coast	24	25	1,560	553	1,458	3,620
Total:						
1968	3,422	1,125	[1] 4,243	7,311	2,995	19,096
1967	1,611	1,111	4,393	6,999	2,371	16,485

[1] Specialty oils include: Insulating, 113; medicinal, 236; rust preventatives, 2; sand-frac, 2; spray oils, 221; and other, 3,669.

Table 56.—Petroleum oils crude, refined and unfinished oils, imported into the United States, by months[1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1967													
Crude petroleum	41,107	29,220	37,585	38,219	39,880	33,640	30,092	31,458	31,458	31,890	29,622	37,478	411,649
Petroleum products:													
Motor gasoline	1,472	1,623	1,202	1,891	1,818	1,063	771	823	1,244	1,129	1,101	1,078	15,215
Special naphthas	1	2	146	1	2	3	1	2	2	148	64	3	375
Kerosine	-------	-------	-------	33	-------	-------	-------	-------	-------	-------	-------	-------	33
Distillate fuel oil	1,148	895	2,696	1,378	1,302	1,327	893	1,054	1,155	1,681	1,435	3,528	18,492
Residual fuel oil	44,340	38,327	41,108	36,542	30,839	26,587	23,128	26,472	24,208	35,406	31,038	37,944	395,939
Jet fuel:													
Naphtha type	237	177	682	622	159	767	959	417	262	499	289	380	5,450
Kerosine type	1,983	1,512	1,662	1,683	2,113	2,374	2,600	2,739	1,786	3,625	2,268	2,596	26,941
Total	2,220	1,689	2,344	2,305	2,272	3,141	3,559	3,156	2,048	4,124	2,557	2,976	32,391
Lubricants	3	1	2	3	3	4	4	4	4	3	5	4	40
Wax	1	-------	6	-------	-------	-------	6	-------	1	-------	6	-------	20
Asphalt (incl. natural)	859	90	238	247	343	716	733	819	770	539	813	280	6,447
Liquefied gases:													
Butane	682	792	446	339	366	339	321	408	399	484	606	513	5,695
Propane	448	548	461	298	285	209	139	192	238	389	451	532	4,190
Total	1,130	1,340	907	637	651	548	460	600	637	873	1,057	1,045	9,885
Petrochemical feedstocks	21	-------	21	86	-------	-------	-------	76	-------	-------	76	-------	280
Unfinished oils	4,138	2,673	3,338	3,230	3,220	3,623	2,388	2,343	2,667	2,643	2,436	2,526	35,225
Total petroleum products	55,333	46,640	52,008	46,353	40,450	37,012	31,943	35,349	32,736	46,546	40,588	49,384	514,342
Total crude and products	96,440	75,860	89,593	84,572	80,330	70,652	62,035	66,807	64,194	78,436	70,210	86,862	925,991
1968 p													
Crude petroleum	30,537	28,152	35,506	32,459	37,462	40,212	45,717	43,243	42,474	45,912	40,779	49,870	472,323
Petroleum products:													
Motor gasoline	1,182	816	1,761	2,046	1,935	2,082	2,610	2,130	1,739	1,931	1,760	1,599	21,591
Special naphthas	149	2	95	2	73	64	273	2	2	198	275	264	1,399
Kerosine	-------	-------	-------	1	-------	31	-------	30	-------	-------	-------	128	190
Distillate fuel oil	3,745	3,512	4,794	2,837	2,024	2,509	2,946	2,226	2,586	2,217	2,511	4,651	36,558
Residual fuel oil	50,932	42,287	46,446	32,657	27,801	30,949	30,473	26,121	31,278	32,575	31,782	38,260	421,561
Jet fuel:													
Naphtha type	476	689	641	613	494	1,076	480	378	464	437	473	896	7,117
Kerosine type	2,261	2,965	1,903	2,595	2,272	1,893	3,139	3,044	2,636	3,002	2,334	2,331	30,375
Total	2,737	3,654	2,544	3,208	2,766	2,969	3,619	3,422	3,100	3,439	2,807	3,227	37,492
Lubricants	3	3	4	2	2	2	3	3	3	3	3	2	33
Wax	-------	-------	1	6	1	-------	1	2	6	-------	-------	-------	17

See footnotes at end of table.

Table 56.—Petroleum oils crude, refined and unfinished oils, imported into the United States, by months [1]—Continued

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Asphalt (incl. natural)	422	319	101	195	339	1,225	756	429	821	836	441	352	6,236
Liquefied gases:													
Butane	1,003	596	394	230	318	226	339	394	520	521	658	821	6,020
Propane	750	625	503	459	407	299	241	229	369	544	500	701	5,627
Total	1,753	1,221	897	689	725	525	580	623	889	1,065	1,158	1,522	11,647
Unfinished oils	1,987	2,341	1,838	2,079	2,467	2,529	3,426	2,464	2,703	2,789	2,357	2,370	29,350
Total petroleum products	62,910	54,155	58,481	43,722	38,133	42,885	44,687	37,452	43,127	45,053	43,094	52,375	566,074
Total crude and products	93,447	82,307	93,987	76,181	75,595	83,097	90,404	80,695	85,601	90,965	83,873	102,245	1,038,397

p Preliminary.

[1] Imports of crude and unfinished oils reported to the Bureau of Mines; imports of petroleum products compiled from records of the U.S. Department of Commerce.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district

(Thousand barrels)

Country	Crude oil [1]	Gasoline	Special naphtha	Kerosine [2]	Distillate fuel oil [2]	Residual fuel oil [2]	Military jet fuel	Commercial jet fuel	Liquefied gases	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
1967															
North America:															
Canada	150,409	382	26	------	838	1,319	6	1	9,786	160	1,200	33	4	------	164,164
Mexico	------	------	------	------	101	6,959	------	------	19	------	10,744	------	------	------	17,823
Total	150,409	382	26	------	939	8,278	6	1	9,805	160	11,944	33	4	------	181,987
Central America and Caribbean:															
Bahamas	------	------	------	------	------	122	------	------	------	------	------	------	------	------	122
Dominican Republic	------	------	------	------	------	------	------	------	11	6	------	------	------	------	17
Leeward and Windward Islands	------	------	------	------	------	346	------	------	------	------	------	------	------	------	346
Netherlands Antilles	------	486	288	------	4,965	106,634	2,583	12,579	------	3,357	191	------	------	------	131,083
Panama	------	241	------	------	116	852	------	257	------	------	------	------	------	------	1,466
Puerto Rico	------	12,507	------	------	5,942	2,822	------	------	------	------	------	------	------	280	21,551
Trinidad and Tobago	------	4	------	------	295	53,205	1,437	3,279	------	16	2,143	------	------	------	60,379
Virgin Islands	------	1,186	------	33	1,808	9,439	------	------	------	------	938	------	------	------	13,404
Total	------	14,424	288	33	13,126	173,420	4,020	16,115	11	3,379	3,272	------	------	280	228,368

South America:															
Argentina	------	------	------	------	------	4,371	------	------	------	------	------	------	------	------	4,371
Bolivia	7,016	------	------	------	------	------	------	------	------	------	275	------	------	------	7,291
Brazil	------	------	------	------	------	591	------	------	------	------	------	------	------	------	591
Chile	633	------	------	------	------	------	------	------	------	------	------	------	------	------	633
Colombia	11,855	------	------	------	34	4,989	------	------	------	------	457	------	------	------	17,335
Peru	------	------	------	------	------	------	------	------	------	------	113	------	------	------	113
Venezuela	131,089	409	61	------	4,334	179,408	1,424	9,825	38	2,842	12,766	------	------	------	342,196
Total	150,593	409	61	------	4,368	189,359	1,424	9,825	38	2,842	13,611	------	------	------	372,530
Europe:															
Belgium	------	------	------	------	------	102	------	------	------	------	------	1	------	------	103
France	------	------	------	------	------	565	------	------	------	------	------	------	------	------	565
Germany, West	------	------	------	------	------	------	------	------	------	------	------	1	16	------	17
Italy	------	------	------	------	58	9,714	------	124	------	------	197	------	------	------	10,093
Netherlands	------	------	------	------	------	2,028	------	------	------	66	756	5	------	------	2,855
Rumania	------	------	------	------	------	239	------	------	------	------	------	------	------	------	239
Spain	------	------	------	------	------	1,096	------	------	------	------	260	------	------	------	1,356
United Kingdom	------	------	------	------	------	3,909	------	------	------	------	------	------	------	------	3,909
Yugoslavia	------	------	------	------	1	------	------	------	------	------	------	------	------	------	1
Total	------	------	------	------	59	17,653	------	124	------	66	1,213	7	16	------	19,138
Middle East:															
Abu Dhabi	1,936	------	------	------	------	------	------	------	------	------	------	------	------	------	1,936
Aden	------	------	------	------	------	2,132	------	------	------	------	------	------	------	------	2,132
Bahrain	------	------	------	------	------	711	------	------	------	------	108	------	------	------	819
Iran	23,781	------	------	------	------	1,678	------	------	------	------	493	------	------	------	25,952
Iraq	1,716	------	------	------	------	------	------	------	------	------	------	------	------	------	1,716
Kuwait	6,859	------	------	------	------	109	------	------	------	------	1,401	------	------	------	8,369
Neutral Zone	4,006	------	------	------	------	------	------	------	------	------	------	------	------	------	4,006
Saudi Arabia	29,679	------	------	------	------	791	------	------	29	------	965	------	------	------	31,464
Total	67,977	------	------	------	------	5,421	------	------	29	------	2,967	------	------	------	76,394
Africa:															
Algeria	1,447	------	------	------	------	265	------	------	------	------	------	------	------	------	1,712
Angola	------	------	------	------	------	181	------	------	------	------	------	------	------	------	181
Canary Islands	------	------	------	------	------	606	------	876	------	------	------	------	------	------	1,482
Gabon	661	------	------	------	------	------	------	------	------	------	------	------	------	------	661
Ivory Coast	------	------	------	------	------	124	------	------	------	------	------	------	------	------	124
Libya	15,293	------	------	------	------	------	------	------	------	------	------	------	------	------	15,293
Nigeria	1,432	------	------	------	------	402	------	------	------	------	------	------	------	------	1,834
South Africa, Republic of	------	------	------	------	------	227	------	------	------	------	------	------	------	------	227
United Arab Republic	1,318	------	------	------	------	------	------	------	------	------	------	------	------	------	1,318
Total	20,151	------	------	------	------	1,805	------	876	------	------	------	------	------	------	22,832

See footnotes at end of table.

Table 57.—Crude oil and petroleum products imported into the United States, by country and receiving district—Continued

(Thousand barrels)

Country	Crude oil [1]	Gasoline	Special naphtha	Kerosine [2]	Distillate fuel oil [2]	Residual fuel oil [2]	Military jet fuel	Commercial jet fuel	Liquefied gases	Asphalt	Unfinished oils [1]	Lubricants	Wax	Petrochemical feedstocks	Total
Asiatic area:															
Indonesia	22,519	------	------	------	------	------	------	------	------	------	1,744	------	------	------	24,263
Japan	------	------	------	------	------	3	------	------	2	------	474	------	------	------	479
Total	22,519	------	------	------	------	3	------	------	2	------	2,218	------	------	------	24,742
Total imports	411,649	15,215	375	33	18,492	395,939	5,450	26,941	9,885	6,447	35,225	40	20	280	925,991
Imports by PAD Districts:															
District I	216,920	9,465	356	33	16,851	383,260	1,500	17,240	189	5,328	23,222	23	20	------	674,407
District II	56,408	41	19	------	224	587	------	538	5,591	157	20	14	------	------	63,599
District III	672	------	------	------	891	7,475	------	247	18	961	276	1	------	280	10,821
District IV	6,648	------	------	------	------	60	------	------	819	------	------	------	------	------	7,527
District V	131,001	5,709	------	------	526	4,557	3,950	8,916	3,268	1	11,707	2	------	------	169,637
1968 p															
North America:															
Canada	169,418	576	21	2	1,529	1,869	278	------	11,421	228	1	23	2	------	185,368
Mexico	------	------	------	------	------	5,807	------	------	1	------	10,793	------	3	------	16,604
Total	169,418	576	21	2	1,529	7,676	278	------	11,422	228	10,794	23	5	------	201,972
Central America and Caribbean:															
Bahamas	------	------	------	------	------	292	------	------	------	------	------	------	------	------	292
Haiti	------	------	------	------	------	474	------	------	------	------	------	------	------	------	474
Leeward and Windward Islands	------	------	------	------	96	------	------	------	------	------	------	------	------	------	96
Netherlands Antilles	------	323	866	------	6,947	113,245	2,067	13,435	------	3,367	2,859	------	------	------	143,109
Panama	------	850	------	------	357	230	103	846	------	------	1,077	------	------	------	2,463
Puerto Rico	------	17,900	------	------	5,896	477	------	------	------	------	------	------	------	------	24,273
Trinidad	------	13	106	------	1,192	57,547	2,144	5,043	------	10	3,102	------	------	------	69,157
Virgin Islands	------	1,898	------	188	6,913	17,335	------	------	------	------	2,175	------	------	------	28,509
Total	------	20,484	972	188	21,401	189,600	4,314	18,824	------	3,377	9,213	------	------	------	268,373
South America:															
Argentina	------	------	------	------	80	4,679	------	------	------	------	------	------	------	------	4,759
Bolivia	6,866	------	------	------	------	------	------	------	------	------	18	------	------	------	6,884
Brazil	------	------	------	------	------	66	------	------	------	------	------	------	------	------	66
Chile	1,975	------	------	------	------	------	------	------	------	------	59	------	------	------	2,034
Colombia	11,981	------	------	------	800	5,936	------	------	------	------	141	------	------	------	18,858
Peru	------	------	------	------	------	------	------	------	------	------	263	------	------	------	263

Venezuela	125,787	580	406	------	11,497	165,788	2,525	10,178	224	2,278	5,444	------	------	------	324,607
Total	146,559	530	406	------	12,377	176,469	2,525	10,178	224	2,278	5,925	------	------	------	357,471
Europe:															
Belgium	------	1	------	------	128	918	------	------	------	------	------	------	------	------	1,047
Denmark	------	------	------	------	------	------	------	------	------	------	27	------	------	------	27
France	------	------	------	------	------	1,233	------	------	------	------	------	------	------	------	1,233
Germany, West	------	------	------	------	------	189	------	------	------	------	------	2	12	------	203
Italy	------	------	------	------	506	19,450	------	241	------	------	------	------	------	------	20,197
Netherlands	------	------	------	------	------	5,071	------	------	------	328	662	7	------	------	6,068
Rumania	------	------	------	------	------	317	------	------	------	------	------	------	------	------	317
Spain	------	------	------	------	527	5,453	------	------	------	------	253	------	------	------	6,233
United Kingdom	------	------	------	------	------	9,862	------	221	------	25	------	1	------	------	10,109
Total	------	1	------	------	1,161	42,493	------	462	------	353	942	10	12	------	45,434
Middle East:															
Abu Dhabi	5,605	------	------	------	------	------	------	------	------	------	231	------	------	------	5,836
Bahrain	------	------	------	------	------	1,278	------	456	------	------	------	------	------	------	1,734
Iran	21,154	------	------	------	------	653	------	289	------	------	287	------	------	------	22,383
Kuwait	15,863	------	------	------	------	------	------	------	------	------	1,741	------	------	------	17,604
Kuwait, Saudi Arabia Neutral Zone	10,749	------	------	------	------	------	------	------	------	------	------	------	------	------	10,749
Saudi Arabia	18,959	------	------	------	90	2,500	------	31	------	------	217	------	------	------	21,797
Total	72,330	------	------	------	90	4,431	------	776	------	------	2,476	------	------	------	80,103
Africa:															
Algeria	1,944	------	------	------	------	107	------	------	------	------	------	------	------	------	2,051
Canary Islands	------	------	------	------	------	------	------	135	------	------	------	------	------	------	135
Gabon	------	------	------	------	------	422	------	------	------	------	------	------	------	------	422
Ivory Coast	------	------	------	------	------	363	------	------	------	------	------	------	------	------	363
Libya	41,591	------	------	------	------	------	------	------	------	------	------	------	------	------	41,591
Nigeria	3,131	------	------	------	------	------	------	------	------	------	------	------	------	------	3,131
United Arab Republic	10,795	------	------	------	------	------	------	------	------	------	------	------	------	------	10,795
Total	57,461	------	------	------	------	892	------	135	------	------	------	------	------	------	58,488
Asiatic area:															
Indonesia	26,555	------	------	------	------	------	------	------	------	------	------	------	------	------	26,555
Japan	------	------	------	------	------	------	------	------	1	------	------	------	------	------	1
Total	26,555	------	------	------	------	------	------	------	1	------	------	------	------	------	26,556
Total imports	472,323	21,591	1,399	190	36,558	421,561	7,117	30,375	11,647	6,236	29,350	33	17	------	1,038,397
Imports by PAD Districts:															
District I	263,866	20,426	1,281	190	33,912	405,967	1,714	19,787	669	5,500	21,987	17	14	------	775,330
District II	78,365	175	13	------	360	573	------	164	5,077	182	1	14	------	------	84,924
District III	641	1	105	------	1,290	8,271	------	392	------	554	109	2	3	------	11,368
District IV	10,058	------	------	------	------	54	------	------	2,199	------	------	------	------	------	12,311
District V	119,393	989	------	------	996	6,696	5,403	10,032	3,702	------	7,253	------	------	------	154,464

ᵖ Preliminary.

[1] Imports of crude and unfinished oils reported to the Bureau of Mines; imports of refined products compiled from records of the U.S. Department of Commerce.

[2] Includes quantities imported duty free for supply of vessels and aircraft engaged in foreign trade.

Table 58.—Petroleum oils, crude and refined, exported from the United States, including shipments to territories and possessions, by months [1]

(Thousand barrels)

Year and class	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1967													
Crude petroleum	27	------	87	251	------	1,830	8,526	8,188	6,033	1,421	124	54	26,541
Refined products:													
Gasoline: [2]													
Motor	25	19	10	11	22	8	135	299	270	15	20	14	848
Aviation	345	344	340	392	75	27	721	388	393	393	467	144	4,029
Total gasoline	370	363	350	403	97	35	856	687	663	408	487	158	4,877
Special naphthas	171	179	152	168	167	158	110	169	146	197	123	236	1,976
Kerosine	13	19	10	13	21	7	11	11	12	2	29	8	156
Distillate fuel oil	117	316	306	423	102	338	428	220	421	642	521	435	4,269
Residual fuel oil	1,578	1,384	1,608	1,281	1,658	1,560	1,956	2,556	2,835	1,857	2,464	1,203	21,940
Jet fuel:													
Naphtha type	216	159	215	90	133	160	241	121	125	43	149	152	1,804
Kerosine type	------	9	1	------	------	------	122	81	------	4	------	------	217
Total jet fuel	216	168	216	90	133	160	363	202	125	47	149	152	2,021
Lubricants	1,274	1,495	1,936	1,755	1,802	1,358	1,445	1,494	1,497	1,611	1,811	1,217	18,695
Wax	145	145	154	175	130	137	128	136	131	166	115	125	1,687
Coke	830	1,550	560	1,554	1,590	1,716	1,484	1,263	1,558	1,490	1,448	1,236	16,279
Asphalt	61	35	42	36	52	22	27	25	40	37	41	41	459
Petrochemical feedstocks	286	56	244	220	237	389	210	438	127	193	422	173	2,995
Liquefied gases (including ethane):													
Butane	62	106	57	183	35	54	38	154	55	98	51	21	914
Propane	184	87	82	66	150	208	62	314	125	187	146	171	1,782
Butane-propane mix	431	618	583	487	509	522	526	508	585	598	604	595	6,566
Total liquefied gases	677	811	722	736	694	784	626	976	765	883	801	787	9,262
Miscellaneous	87	78	93	73	81	79	70	67	62	70	78	65	908
Total refined	5,825	6,599	6,393	6,927	6,764	6,743	7,714	8,244	8,382	7,603	8,489	5,836	85,519
Total crude and refined	5,852	6,599	6,480	7,178	6,764	8,573	16,240	16,432	14,415	9,024	8,613	5,890	112,060
1968 [p]													
Crude petroleum	250	283	41	144	87	226	2	86	76	111	402	94	1,802
Refined products:													
Gasoline: [2]													
Motor	24	16	12	14	44	11	35	18	18	24	17	23	256
Aviation	257	69	233	238	219	121	186	126	179	217	84	125	2,054
Total gasoline	281	85	245	252	263	132	221	144	197	241	101	148	2,310
Special naphthas	130	169	237	180	283	119	292	185	253	145	198	239	2,430
Kerosine	38	34	29	15	15	12	15	12	15	16	64	172	437
Distillate fuel oil	184	296	154	156	169	61	106	81	353	72	56	97	1,785

Residual fuel oil	1,628	1,472	2,245	2,084	2,236	2,175	1,211	1,900	1,271	1,260	1,043	1,487	20,012
Jet fuel:													
Naphtha type	143	180	268	151	194	154	161	239	148	105	172	225	2,140
Kerosine type	------	------	------	------	------	------	------	36	------	------	------	------	36
Total jet fuel	143	180	268	151	194	154	161	275	148	105	172	225	2,176
Lubricants	1,021	1,255	1,662	1,546	1,617	1,624	1,885	1,508	1,820	1,303	1,666	1,311	18,218
Wax	108	105	125	128	146	153	159	132	149	107	153	123	1,588
Coke	1,096	1,565	1,464	1,414	1,827	1,407	1,673	1,709	1,671	1,750	1,802	2,119	19,497
Asphalt	48	50	22	47	32	49	55	37	38	32	32	31	473
Petrochemical feedstocks	147	225	354	230	57	373	144	47	533	330	261	95	2,796
Liquefied gases (including ethane):													
Butane	75	72	32	30	112	148	37	118	39	104	143	273	1,183
Propane	105	244	251	62	65	371	292	86	188	418	268	192	2,542
Butane-propane mix	570	564	527	473	658	649	643	507	583	542	566	601	6,883
Total liquefied gases	750	880	810	565	835	1,168	972	711	810	1,064	977	1,066	10,608
Miscellaneous	62	68	82	92	97	68	108	105	117	65	84	101	1,049
Total refined	5,636	6,384	7,697	6,860	7,771	7,495	7,002	6,846	7,375	6,490	6,609	7,214	83,379
Total crude and refined	5,886	6,667	7,738	7,004	7,858	7,721	7,004	6,932	7,451	6,601	7,011	7,308	85,181

---

p Preliminary.

[1] Compiled from records of U.S. Department of Commerce.

[2] Includes benzol, natural gasoline, and antiknock compounds.

Table 59.—Crude petroleum and products exported from the United States by countries of destination and shipments to and exports from territories and possessions

	Crude petroleum	Gasoline	Special naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1967															
North America:															
Canada	3,688	160	719	------	25	1,076	7,389	2,031	49	364	118	2,373	89	128	18,209
Mexico	18	153	49	17	------	1,903	2,032	551	163	7,551	230	295	8	47	13,017
Netherlands Antilles	------	(1)	------	------	------	------	623	17	1	------	1	------	(1)	(1)	642
Trinidad and Tobago	645	------	------	------	------	10	134	17	(1)	------	4	------	1	1	812
Other	------	30	38	4	4	86	1,753	396	14	89	114	15	109	18	2,670
Total	4,351	343	806	21	29	3,075	11,931	3,012	227	8,004	467	2,683	207	194	35,350
South America:															
Argentina	------	(1)	2	------	------	------	(1)	183	(1)	79	1	------	1	3	269
Brazil	------	287	19	------	10	------	(1)	1,402	5	78	41	97	151	40	2,130
Chile	------	(1)	(1)	------	1	(1)	------	201	4	------	35	------	1	4	246
Colombia	------	------	2	------	(1)	------	(1)	62	1	(1)	78	------	2	11	156
Peru	(1)	(1)	------	------	------	843	251	198	1	(1)	24	------	2	4	1,323
Venezuela	------	(1)	20	------	1	(1)	(1)	40	1	(1)	4	1	3	10	80
Other	------	1	5	------	(1)	------	------	166	2	------	59	------	1	6	240
Total	(1)	288	48	------	12	843	251	2,252	14	157	242	98	161	78	4,444
Europe:															
Belgium-Luxembourg	188	(1)	27	------	------	------	76	604	1	23	8	1,046	9	20	2,002
Denmark	447	(1)	(1)	------	(1)	------	------	41	------	(1)	11	(1)	3	9	511
France	------	(1)	61	------	(1)	1	(1)	134	30	(1)	49	502	452	8	1,237
Germany, West	2,121	(1)	296	------	28	258	47	238	2	(1)	269	772	56	11	4,098
Greece	------	34	(1)	19	------	------	5	16	1	(1)	1	164	1	1	242
Italy	465	202	29	------	4	33	21	530	32	2	78	1,361	629	15	3,401
Netherlands	833	410	91	------	(1)	1,059	244	381	(1)	29	36	1,345	402	17	4,847
Norway	------	------	(1)	------	(1)	------	------	33	(1)	------	2	815	3	5	858
Spain	550	28	22	------	------	------	106	31	(1)	------	38	414	205	22	1,416
Sweden	------	(1)	------	------	(1)	120	------	203	1	------	9	96	105	9	543
United Kingdom	16,959	1,790	279	1	------	108	761	1,165	1	1,025	57	251	68	56	22,521
Other	------	77	4	220	(1)	152	2	100	3	(1)	40	148	7	14	767
Total	21,563	2,541	809	240	32	1,731	1,262	3,476	71	1,079	598	6,914	1,940	187	42,443
Africa:															
Congo (Kinshasa)	------	(1)	4	------	(1)	------	------	30	3	------	4	------	(1)	1	42
South Africa, Republic of	------	(1)	42	------	2	------	165	483	5	1	110	(1)	24	37	869
United Arab Republic	------	------	3	------	------	------	------	76	(1)	------	------	------	1	1	81
Other	1	208	8	------	5	2	370	285	3	1	35	251	5	14	1,188
Total	1	208	57	------	7	2	535	874	11	2	149	251	30	53	2,180

Asia:															
India	------	1	6	------	2	------	(1)	2,436	(1)	1	8	------	2	55	2,511
Indonesia	------	(1)	(1)	------	------	------	------	178	(1)	------	2	------	(1)	6	186
Japan	626	2	453	------	24	56	8,099	2,905	2	6	61	6,028	188	114	18,564
Malaysia	------	(1)	------	------	------	------	(1)	12	(1)	(1)	2	28	(1)	3	45
Philippines	------	(1)	23	------	------	(1)	------	447	3	(1)	17	22	7	26	545
Turkey	------	54	4	9	2	------	(1)	616	1	(1)	1	------	4	7	698
Other	(1)	90	25	13	(1)	6	------	1,286	14	1	68	56	25	51	1,635
Total	626	147	511	22	28	62	8,099	7,880	20	8	159	6,134	226	262	24,184
Oceania:															
Australia	------	(1)	48	------	19	------	7	212	3	3	51	199	415	71	1,028
French Pacific Islands	------	75	(1)	------	23	328	65	5	(1)	1	------	------	(1)	(1)	497
New Zealand	------	(1)	20	------	3	------	(1)	55	(1)	2	10	------	4	48	142
Other	------	------	(1)	------	5	------	------	5	2	(1)	(1)	------	(1)	(1)	12
Total	------	75	68	------	50	328	72	277	5	6	61	199	419	119	1,679
Grand total	26,541	3,602	2,299	283	158	6,041	22,150	17,771	348	9,256	1,676	16,279	2,983	893	110,280
Shipments from the United States to territories and possessions:															
Puerto Rico	------	1,315	(2)		84	7	2	(2)	(2)	(2)	(2)	------	(2)	10	[3]2,451
Virgin Islands	(1)	31	(2)		------	9	------	(2)	(2)	(2)	(2)	------	(2)	(1)	[3]78
Wake	------	600	(2)		1,652	467	1	(2)	(2)	(2)	(2)	------	(2)	(1)	[3]2,741
	(1)		(2)					(2)	(2)	(2)	(2)	------	(2)	(1)	
Total	------	1,946	(2)		1,736	483	3	(2)	(2)	(2)	(2)	------	(2)	10	[3]5,270
Exports from territories to foreign countries: Puerto Rico	------	671	342		(1)	2,255	213	5	------	4	------	------	(1)	(1)	3,490
Total net shipments from the United States	26,541	4,877	[3]1,976		2,177	4,269	21,940	[3]18,695	[3]459	[3]9,262	[3]1,687	16,279	[3]2,995	903	[3]112,060

[1] Less than ½ unit.
[2] Not separately classified.
[3] Includes data not separately classified.

Table 59.—Crude petroleum and products exported from the United States by countries of destination and shipments to and exports from territories and possessions—Continued

	Crude petroleum	Gasoline	Special naphtha	Jet fuel	Kerosine	Distillate oil	Residual oil	Lubricating oil	Asphalt	Liquefied petroleum gases	Wax	Coke	Petrochemical feedstocks	Miscellaneous products	Total
1968															
North America:															
Canada	5	140	380	------	280	556	6,812	2,096	64	410	112	2,861	207	135	14,058
Mexico	114	88	203	14	(1)	53	1,665	671	135	7,677	226	369	8	31	11,254
Trinidad and Tobago	283	1	27	------	------	------	------	13	1	------	4	------	1	1	331
Other	------	90	231	4	2	10	474	414	23	82	118	47	45	16	1,556
Total	402	319	841	18	282	619	8,951	3,194	223	8,169	460	3,277	261	183	27,199
South America:															
Argentina	------	(1)	2	------	(1)	185	1	136	(1)	462	2	(1)	3	1	792
Brazil	------	345	30	------	2	------	7	1,752	29	377	95	103	155	82	2,977
Chile	------	------	2	------	1	------	(1)	235	2	48	25	------	1	13	327
Colombia	------	1	4	------	(1)	1	(1)	42	1	(1)	78	------	2	11	140
Peru	------	(1)	1	------	------	2	395	157	2	------	16	(1)	2	4	597
Other	------	16	27	------	1	2	(1)	186	12	1	49	1	4	24	323
Total	------	362	66	------	4	190	403	2,508	46	888	265	104	167	135	5,138
Europe:															
Belgium-Luxembourg	------	(1)	12	------	1	------	------	605	2	25	7	817	9	13	1,491
France	(1)	1	49	------	1	------	89	60	17	114	51	554	502	12	1,450
Germany, West	------	137	275	------	25	6	139	420	2	(1)	213	445	146	30	1,838
Greece	------	7	1	------	(1)	------	------	24	(1)	(1)	(1)	122	1	(1)	155
Italy	------	5	17	------	1	20	754	490	13	(1)	73	1,634	8	47	3,062
Netherlands	------	263	255	------	(1)	702	149	665	1	(1)	35	1,057	377	25	3,529
Norway	------	------	(1)	------	------	------	(1)	26	(1)	------	2	1,136	2	5	1,171
Spain	------	(1)	23	------	------	------	105	32	(1)	50	17	406	279	17	929
Sweden	------	(1)	1	------	------	------	(1)	157	2	------	10	159	79	12	420
United Kingdom	352	15	334	------	17	217	1,290	1,090	2	1,345	35	271	147	76	5,191
Other	------	66	2	223	(1)	164	1	131	3	(1)	40	151	11	16	808
Total	352	494	969	223	45	1,109	2,527	3,700	42	1,534	483	6,752	1,561	253	20,044
Africa:															
Congo (Kinshasa)	------	(1)	3	------	(1)	------	(1)	47	1	------	(1)	------	2	(1)	53
South Africa, Republic of	------	163	47	------	1	------	321	358	5	2	89	32	33	38	1,089
Other	------	273	10	------	7	------	1	221	11	(1)	59	273	9	22	886
Total	------	436	60	----	8	------	322	626	17	2	148	305	44	60	2,028

Asia:															
India	------	20	1	------	1	------	1	1,955	(1)	1	3	30	1	65	2,078
Indonesia	(1)	(1)	(1)	------	------	------	------	154	(1)	(1)	(1)	------	(1)	7	161
Japan	1,048	8	618	------	59	18	7,493	2,415	1	1	68	8,509	235	141	20,614
Malaysia	------	------	4	------	------	------	------	15	(1)	------	3	133	(1)	2	157
Philippines	------	(1)	24	------	2	------	------	378	2	(1)	25	------	4	21	456
Turkey	------	23	1	------	1	------	------	694	------	------	(1)	------	4	19	742
Other	(1)	5	60	------	3	1	2	1,629	17	(1)	52	134	26	48	1,977
Total	1,048	56	708	------	66	19	7,496	7,240	20	2	151	8,806	270	303	26,185
Oceania:															
Australia	------	15	83	------	7	4	4	308	2	4	59	264	473	69	1,292
French Pacific Islands	------	71	1	17	17	340	306	4	(1)	(1)	------	------	(1)	(1)	756
New Zealand	------	(1)	23	------	1	------	(1)	68	(1)	2	10	------	5	35	144
Other	------	------	(1)	------	1	1	------	8	7	1	(1)	------	(1)	(1)	18
Total	------	86	107	17	26	345	310	388	9	7	69	264	478	104	2,210
Grand total	1,802	1,753	2,751	258	431	2,282	20,009	17,656	357	10,602	1,576	19,508	2,781	1,038	82,804
Shipments from the United States to territories and possessions: [2]															
Puerto Rico	1	154	(3)		(1)	3	4	(3)	(3)	(3)	12	------	(3)	2	[4] 621
Virgin Islands	------	40	(3)		(1)	11	(3)	(3)	(3)	(3)	(3)	------	(3)	(1)	[4] 79
Other [5]	------	510	(3)		1,797	415	------	13	2	(3)	(3)	------	(3)	------	2,737
Total	1	704	(3)		1,797	429	4	13	2	(3)	12	------	(3)	2	[4] 3,437
Exports from Puerto Rico to foreign countries	(1)	396	201		(1)	845	(1)	3	5	3	------	------	------	(1)	1,453
Total net shipments from the United States [6]	1,803	2,061	2,550		2,486	1,866	20,013	17,666	354	10,599	1,588	19,508	2,781	1,040	[4] 84,788

---

[1] Less than ½ unit.
[2] Shipments are 12 months 1968.
[3] Not separately classified.
[4] Includes data not separately classified.
[5] Data reported by shippers to the Bureau of Mines.
[6] The figures shown in this table may vary from export data shown in other sections of this chapter because of late changes in Bureau of Census data which could not be incorporated into the other tables.

Table 60.—World production of crude petroleum by countries

(Thousand barrels)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada	274,626	296,419	320,543	351,292	377,695
Cuba [e]	248	382	460	756	800
Mexico	115,576	117,959	121,149	133,042	142,257
Trinidad and Tobago	49,731	48,859	55,603	64,995	66,904
United States	2,786,822	2,848,514	3,027,763	3,215,742	3,329,042
South America:					
Argentina	[r] 100,276	[r] 98,276	[r] 104,760	114,673	125,488
Bolivia	3,290	3,357	6,085	14,527	14,991
Brazil	33,310	34,342	42,446	53,515	59,816
Chile	13,687	12,704	12,428	12,369	13,695
Colombia	62,596	72,670	71,430	68,877	63,435
Ecuador	[r] 2,887	[r] 2,921	2,660	2,272	1,815
Peru	23,119	23,068	23,027	25,857	27,135
Venezuela	1,241,782	1,267,602	1,230,464	1,292,876	1,319,340
Europe:					
Albania	5,096	[r] 5,506	[r] 5,941	6,593	[e] 7,000
Austria	18,571	19,908	19,228	18,725	[e] 18,000
Bulgaria	1,168	1,672	2,920	3,642	4,015
Czechoslovakia	1,322	1,301	1,288	1,424	[e] 1,500
France	[r] 20,491	[r] 21,772	21,365	20,640	19,585
Germany, West	55,419	56,945	56,832	57,257	57,655
Hungary	[r] 13,742	[r] 13,749	13,009	12,864	14,398
Italy	18,184	15,055	11,974	11,010	10,262
Netherlands	15,758	16,630	16,438	15,438	14,620
Poland	2,092	2,514	2,971	3,339	3,525
Rumania	[r] 92,380	[r] 93,692	[r] 95,585	98,424	99,013
Spain	----------	----------	197	560	[e] 1,050
U.S.S.R.[1]	1,643,500	1,786,000	1,948,000	2,100,000	2,252,000
United Kingdom	939	606	568	641	597
Yugoslavia	13,322	15,281	16,460	17,655	18,473
Africa:					
Algeria	204,711	201,754	257,122	282,200	325,064
Angola	6,535	4,734	4,560	3,880	5,401
Congo (Brazzaville)	627	535	467	376	341
Gabon, Republic of	7,668	9,161	10,484	25,203	33,630
Libya	315,660	445,374	552,712	636,504	948,519
Morocco	910	782	783	738	620
Nigeria	43,997	99,354	152,428	116,519	52,854
Tunisia	----------	----------	4,741	17,068	23,503
United Arab Republic	43,915	45,556	[r] 44,070	[2] 39,547	[2] 52,338
Asia:					
Bahrain	18,000	20,788	22,521	25,370	27,598
Brunei	25,913	28,991	[r] 34,626	37,961	44,664
Burma	[r] 4,164	4,065	4,255	4,392	5,761
China, mainland [e]	62,050	73,000	95,000	80,300	110,000
India	16,965	22,494	[r] 35,624	42,190	43,552
Indonesia	171,492	178,991	168,429	186,231	219,912
Iran	618,731	688,213	771,234	947,678	1,039,366
Iraq	461,961	482,461	505,428	445,821	550,098
Israel	1,440	1,469	1,359	[3] 8,687	[3] 14,831
Japan	[r] 4,597	[r] 4,698	[r] 5,443	5,520	5,476
Kuwait	774,815	791,903	830,537	836,719	886,125
Kuwait-Saudi Arabia Neutral Zone	131,415	132,285	[r] 153,432	151,461	[e] 157,000
Malaysia (Sarawak)	352	351	346	328	1,521
Mongolia	[e] [r] 125	116	89	[e] 90	[e] 90
Muscat and Oman	----------	----------	----------	23,030	87,854
Pakistan	[r] 3,751	[r] 3,992	[r] 3,721	3,636	3,832
Qatar	77,885	84,215	105,945	118,083	124,220
Saudi Arabia	628,095	739,078	873,349	948,110	1,035,773
Taiwan	61	131	226	246	421
Thailand [e]	[r] 18	[r] 14	[r] 14	14	26
Trucial States	67,465	102,804	131,531	139,467	181,756
Turkey	[r] 6,387	[r] 10,823	[r] 14,500	19,515	22,235
Oceania:					
Australia	1,491	2,622	3,390	7,594	15,228
New Zealand	4	4	4	3	2
Total	[r] 10,311,134	[r] 11,058,462	[r] 12,019,964	12,873,486	14,083,717

[e] Estimate. [p] Preliminary. [r] Revised.

[1] U.S.S.R. in Asia (including Sakhalin) included with U.S.S.R. in Europe.

[2] Excludes Israeli production of Egyptian oilfields.

[3] Includes estimates of Israeli production of Egyptian oilfields.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/71

Phosphate Rock

By Donald E. Eilertsen[1]

World production and U.S. production, exports and producers' yearend stocks of marketable phosphate rock shattered all previous records, but the usual record-breaking apparent consumption faltered for the first time in more than 25 years to become the third largest amount.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Salient phosphate rock statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Mine production	74,473	84,305	112,960	128,973	148,336
Marketable production	25,715	[r] 29,482	39,044	39,770	41,251
Value	$161,067	[r] $193,323	$261,092	$265,947	$250,692
Average per ton	$6.26	$6.55	$6.69	$6.69	$6.08
Sold or used by producers	24,731	29,039	36,448	37,835	37,319
Value	$156,738	$188,590	$245,182	$251,163	$228,347
Average per ton	$6.34	$6.49	$6.73	$6.64	$6.12
Imports for consumption	175	148	178	139	116
Value	$3,329	$2,980	$4,256	$3,261	$2,679
Average per ton	$19.02	$20.14	$23.91	$23.46	$23.09
Exports [1]	6,374	7,323	9,248	10,072	12,099
P_2O_5 content	2,055	2,318	2,808	3,290	3,671
Value	$39,717	$51,109	$65,952	$69,479	$75,653
Average per ton	$6.23	$6.98	$7.13	$6.90	$6.25
Consumption, apparent [2]	18,532	21,864	27,378	27,902	25,336
World: Production	62,719	70,298	83,194	86,133	92,838

[r] Revised.
[1] From table 6.
[2] Measured by sold or used plus imports minus exports.

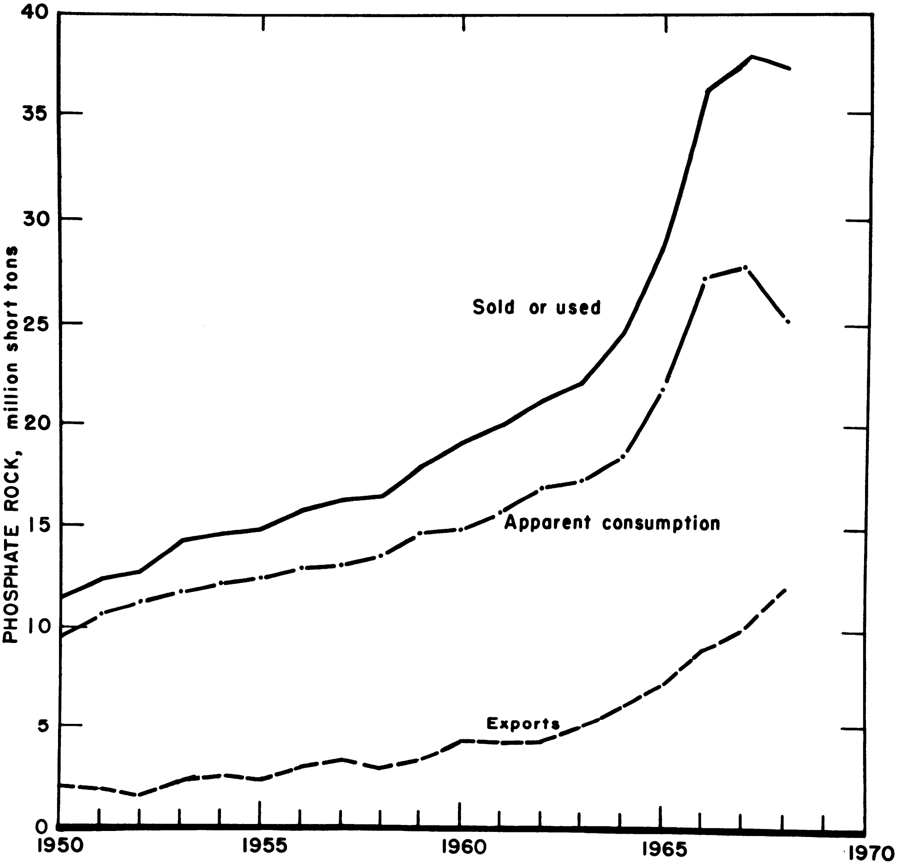

Figure 1.—Phosphate rock (sold or used), apparent consumption, and exports.

DOMESTIC PRODUCTION

Marketable phosphate rock production increased for the 11th consecutive year, and the 1968 output broke all records.

Phosphate rock was produced in eight States in 1968, with Florida the leading producer. Land-pebble phosphate rock was produced in Florida by Agrico Chemical Co., American Cyanamid Co., U.S. Agri-Chemicals Inc., Borden Chemical Co., W. R. Grace & Co., International Minerals & Chemical Corp., Minerals Recovery Corp., Mobil Chemical Co., Occidental Chemical Co., Swift & Co., and U.S. Phosphoric Products Co. Soft phosphate rock was produced in Florida by Howard Phosphate Co., M. W. Kellogg Co., Loncola Phosphate Co., Soil Builders, Inc., and Sun Phosphate Co. Some phosphate rock was produced in California for the first time, by Cuyama Phosphate Corp. Phosphate rock was also produced in Idaho by Stauffer Chemical Co., Monsanto Chemical Co., Mountain Fuel Supply Co., and J. R. Simplot Co.; in Montana by Stauffer Chemical Co., Cominco American, Inc., Eich, A. G. Jackson, and Relyea Mines; in Tennessee by Hooker Chemical Co., Monsanto Co., Presnell Phosphate Co., Inc., Stauffer Chemical Co., Tennessee Valley Authority, and M. C. West, Inc.; in North Carolina by Texas Gulf Sulphur Co.; and in Utah and Wyoming by San Francisco Chemical Co.

Freeport Chemical Co., a new division of Freeport Sulphur Co., began production of phosphoric acid at its complex at Uncle Sam, La., in August. The complex, located on the Mississippi River between New Orleans and Baton Rouge, was designed to produce 1.1 million tons of commercial 54-percent phosphoric acid annually containing 600,000 tons of phosphate plant nutrient, commonly known as phosphorus pentoxide (P_2O_5). The complex also has a sulfuric acid plant, the sulfur for which is barged from Freeport's nearby Port Sulfur shipping point. Phosphate rock is obtained mostly from mine and beneficiation facilities near Fort Meade, Fla., which are jointly owned by Freeport and U.S. Agri-Chemicals, Inc., a subsidiary of United States Steel Corp.

Occidental Chemical Co. reported that it shipped 2.35 million tons of all grades of phosphate rock from its Suwanee River mine in 1968, compared with 1.5 million tons in 1967. A $4.35 million capital appropriation was approved for the construction of a new 100,000-ton-per-year defluorinated phosphate plant at the Suwanee River complex to keep pace with the animal-feed supplements industry. This new plant will replace the obsolete 50,000-ton-per-year Houston plant.

Texas Gulf Sulphur Co. reported that it

Table 2.—Production of phosphate rock in the United States, by States

(Thousand short tons and thousand dollars)

State	Mine production		Mine production used directly		Washer production		Marketable production		
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Value
1967									
Florida [1]	117,641	16,731	35	8	31,875	10,284	31,910	10,291	$207,788
Tennessee	5,332	1,264	574	142	2,418	653	2,992	795	22,571
Western States [2]	6,000	1,509	2,941	772	1,927	606	4,868	1,378	35,588
Total [3]	128,973	19,503	3,551	922	36,220	11,542	39,770	12,464	265,947
1968									
Florida [1]	135,891	26,126	29	6	33,004	10,628	33,032	10,634	193,319
Tennessee	6,777	1,456	685	169	2,464	657	3,149	826	28,628
Western States [2]	5,668	1,443	3,879	1,002	1,191	381	5,070	1,383	38,746
Total [3]	148,336	29,024	4,592	1,177	36,658	11,667	41,251	12,843	250,692

[1] Includes North Carolina.
[2] Includes California (1968), Idaho, Montana, Utah, and Wyoming.
[3] Data may not add to totals shown because of independent rounding.

Table 3.—Florida phosphate rock sold or used by producers, by kinds

(Thousand short tons and thousand dollars)

Year	Rock	P_2O_5 content	Value		Rock	P_2O_5 content	Value	
			Total	Average per ton			Total	Average per ton
	Hard rock				Soft rock			
1964	86	30	$747	$8.69	31	6	$225	$7.26
1965	77	27	684	8.88	31	6	221	7.13
1966	49	17	437	8.92	45	9	293	6.51
1967	--------	------	----------	-------	36	7	266	7.42
1968	--------	------	----------	-------	30	6	224	7.47
	Land pebble				Total [1]			
1964	18,203	5,971	$115,513	$6.35	18,320	6,007	$116,485	$6.36
1965	21,388	6,949	138,744	6.49	21,496	6,982	139,649	6.50
1966 [2]	28,043	9,077	184,075	6.56	28,137	9,103	184,805	6.57
1967 [2]	29,796	9,646	193,283	6.49	29,832	9,654	193,548	6.49
1968 [2]	29,571	9,504	173,190	5.86	29,601	9,510	173,418	5.86

[1] Data may not add to totals shown because of independent rounding.
[2] Includes North Carolina.

produced 443,550 tons of 54-percent phosphoric acid, 62,800 tons of 70-percent phorphoric acid, and 183,350 tons of diammonium phosphate in 1968 at Lee Creek, N.C.

FMC Corp. reportedly obtained options to acquire 3,000 acres of phosphate-bearing lands in Beaufort County, N.C. The phosphate ore is deeper than that mined by open-pit methods in North Carolina by Texas Gulf Sulphur Co. FMC will mine the ore by underground hydraulic methods which the firm developed while studying the deposits.[2]

CONSUMPTION AND USES

Apparent consumption was 9 percent less than that of 1967, and this was the first time in more than 25 years that it broke no records. Producers of phosphate rock likewise sold or used 9 percent less rock for domestic use in 1968 than they did in 1967 (table 7), and of the four major uses, only that for electric furnace phosphorus increased.

According to a U.S. Department of Agriculture preliminary report, fertilizers (mixtures and direct-application materials) consumed during the fiscal year ending June 30, 1968, contained 4,354,891 tons of available P_2O_5 compared with 4,304,688 tons for the preceding 12-month period.[3]

---

[2] Industrial Minerals (London). FMC Buys Carolina Rock Phosphate Reserves. No. 15, December 1968, p. 32.

[3] U.S. Department of Agriculture. Consumption of Commercial Fertilizers in the United States. Preliminary Rept. SpCr 7, Oct. 23, 1968, 11 pp.

Table 4.—Tennessee phosphate rock sold or used by producers

(Thousand short tons and thousand dollars)

Year	Rock	P_2O_5 content	Value	
			Total	Average per ton
1964	2,753	722	$19,074	$6.93
1965	2,969	772	22,385	7.54
1966	3,076	799	23,497	7.64
1967	3,032	808	22,494	7.42
1968	3,065	807	23,646	7.71

Table 5.—Phosphate rock sold or used by producers in the United States, by grades and States

(Thousand short tons)

Year and grade B.P.L. content[3] (percent)	Florida[1]		Tennessee		Western States		Total[2] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1967								
Below 60	36	7	2,171	561	2,305	559	4,512	1,128
60–66	1,375	408	792	224	383	112	2,550	744
66–70	13,078	4,091	--------	--------	693	214	13,771	4,305
70–72	1,736	558	43	13	1,455	462	3,234	1,034
72–74	6,257	2,071	27	9	128	43	6,412	2,123
Plus 74	7,351	2,518	--------	--------	7	2	7,358	2,520
Total[2]	29,832	9,654	3,032	808	4,971	1,393	37,835	11,855
1968								
Below 60	44	10	2,214	563	2,884	720	5,142	1,293
60–66	1,519	435	753	212	19	6	2,291	653
66–70	11,949	3,698	--------	--------	951	292	12,900	3,990
70–72	2,612	836	98	32	559	177	3,269	1,045
72–74	7,005	2,314	--------	--------	95	31	7,099	2,345
Plus 74	6,471	2,218	--------	--------	146	50	6,616	2,267
Total[2]	29,601	9,510	3,065	807	4,653	1,276	37,319	11,594

[1] Includes North Carolina.

[2] Data may not add to totals shown because of independent rounding.

[3] Bone phosphate of lime, $Ca_3(PO_4)_2$.

Table 6.—Phosphate rock sold or used by producers, by uses and States

(Thousand short tons)

Use	Florida [1]		Tennessee		Western States		Total [2] United States	
	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content	Rock	P_2O_5 content
1967								
Domestic:								
Agricultural	20,461	6,582	W	W	1,280	407	W	W
Industrial	357	107	W	W	2,633	660	W	W
Total	20,817	6,689	3,032	808	3,914	1,068	27,763	8,565
Exports	9,015	2,965	--------	--------	1,057	325	10,072	3,290
Total	29,832	9,654	3,032	808	4,971	1,393	37,835	11,855
1968								
Domestic:								
Agricultural	18,054	6,015	--------	--------	1,030	328	19,084	6,343
Industrial	365	109	3,065	807	2,706	663	6,136	1,580
Total	18,419	6,124	3,065	807	3,736	991	25,220	7,923
Exports	11,182	3,386	--------	--------	917	285	12,099	3,671
Total	29,601	9,510	3,065	807	4,653	1,276	37,319	11,594

W Withheld to avoid disclosing individual company confidential data.

[1] Includes North Carolina.

[2] Data may not add to totals shown because of independent rounding.

Table 7.—Phosphate rock sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1967			1968		
	Rock	P_2O_5 content	Value	Rock	P_2O_5 content	Value
Domestic:						
Phosphoric acid (wet process)	11,370	3,594	$70,970	9,532	2,979	$52,685
Electric furnace phosphorus	5,987	1,563	40,863	6,117	1,574	42,032
Triple superphosphate	4,433	1,460	29,652	3,858	1,271	23,166
Ordinary superphosphate	5,082	1,661	33,417	3,708	1,452	21,118
Nitraphosphate	883	283	6,718	2,006	646	13,693
Direct application to the soil						
Stock and poultry feed						
Fertilizer filler						
Other fertilizers						
Other uses	8	3	63			
Total [1]	27,763	8,565	181,683	25,221	7,922	152,694
Exports	10,072	3,290	69,479	12,099	3,671	75,653
Grand total [1]	37,835	11,855	251,163	37,319	11,594	228,347

[1] Data may not add to totals shown because of independent rounding.

STOCKS

Producers' yearend stocks of marketable phosphate rock increased 41.6 percent over those of yearend 1967 and were the largest on record.

Table 8.—Producer stocks of marketable phosphate rock, December 31

(Thousand short tons)

Source	1967		1968	
	Rock	P_2O_5 content	Rock	P_2O_5 content
Florida [1]	r 7,857	r 2,503	11,578	3,673
Tennessee	85	23	78	22
Western States	r 2,000	r 511	2,424	621
Total [2]	r 9,942	r 3,037	14,080	4,316

r Revised.

[1] Includes North Carolina.

[2] Data may not add to totals shown because of independent rounding.

PRICES

Prices quoted by Oil, Paint and Drug Reporter for various grades of Florida land-pebble phosphate rock are shown in table 9. Prices of some other phosphoric materials were as follows: Superphosphate, run-of-pile, under 22 percent available phosphoric acid (a.p.a.), pulverized, bulk, carlots, at works was quoted at $0.92 to $1.10 per unit (20 pounds) of P_2O_5; triple superphosphate, 46 percent or more a.p.a., run-of-pile, bulk, carlots, Florida, was quoted at $1.22 to $1.28 per unit until early February at which time the price was $1.28 per unit; agricultural-grade phosphoric acid, 52 to 54 percent a.p.a., tanks, delivered, began at $1.72 to $1.83 per unit and changed early in February to $1.83 per unit. Prices of phosphorus were as follows: Amorphous, red, drums, ton lots, works—$0.55 per pound; white (yellow), solid, drums, carlots, works, freight equalized—$0.225 per pound; and white (yellow), tanks, works, freight equalized—$0.19 per pound.

Table 9.—Prices of Florida land-pebble, unground, washed and dried phosphate rock, in bulk, carlots, at mine, in 1968

(Per short ton)

Grade, percent B.P.L.[1]	Price
66 to 68	$6.50
68 to 70	7.50
70 to 72	8.15
74 to 75	9.20
76 to 77	10.20

[1] 1.0 percent B.P.L. (bone phosphate of lime also known as tricalcium phosphate) = 0.458 percent P_2O_5.

Source: Oil, Paint and Drug Reporter.

FOREIGN TRADE

According to the Bureau of Census, U.S. Department of Commerce, exports of Florida phosphate rock increased 25.5 percent over those of 1967, while exports of other phosphate rock decreased by 30.2 percent. All together there was an unusually large increase of 17.5 percent over 1967 total exports. Exports of non-Florida phosphate rock to Canada were 492,000 tons less in 1968 than those in 1967. The average value of Florida phosphate rock at ports of exportation in 1968 was $8.03 per ton, compared to $15.33 per ton for non-Florida phosphate rock.

Of the 116,000 tons of phosphate rock imported, chiefly for use as low-fluorine-content animal-feed supplement, 78 percent came from the Netherlands Antilles and 21 percent from Mexico.

Table 10.—U.S. exports of phosphate rock, by grades and countries

(Thousand short tons and thousand dollars)

Grade and destination	1967		1968	
	Quantity	Value	Quantity	Value
Florida phosphate rock:				
Australia	603	$5,631	628	$6,281
Austria	46	378	180	1,411
Belgium-Luxembourg	139	1,000	335	2,147
Brazil	201	1,837	296	2,725
Canada	1,218	12,784	1,382	11,606
Chile	--------	--------	64	531
Colombia	35	268	24	160
El Salvador	8	70	14	90
France	135	1,174	223	1,598
Germany, West	1,321	9,262	1,424	9,741
India	87	698	299	2,093
Italy	1,118	8,243	1,368	9,711
Japan	2,132	18,410	2,759	23,742
Korea, South	156	1,577	495	3,405
Malaysia	11	169	12	217
Mexico	361	2,506	368	2,745
Netherlands	147	1,311	224	2,104
New Zealand	140	1,415	115	1,156
Norway	2	15	23	184
Peru	10	85	10	77
Philippines	147	1,317	150	1,210
Rumania	39	302	--------	--------
Spain	263	2,250	270	1,919
Sweden	82	591	11	96
United Kingdom	343	2,934	292	2,535
Uruguay	13	128	23	240
Other	47	378	63	1,029
Total	8,804	74,733	11,052	88,753
Other phosphate rock:[1]				
Belgium-Luxembourg	(2)	12	1	46
Brazil	3	95	8	170
Canada	1,416	18,942	924	13,635
France	8	63	(2)	1
Germany, West	34	207	(2)	13
Iran	--------	--------	15	1,130
Japan	3	18	14	201
Mexico	2	60	1	21
Netherlands	1	121	35	208
Norway	2	15	20	138
Other	9	147	13	243
Total	1,478	19,680	1,031	15,806
Grand total	10,282	94,413	12,083	104,559

---

[1] Includes colloidal matrix, sintered matrix, soft phosphate rock, and Tennessee, Idaho, and Montana rock

[2] Less than ½ unit.

Table 11.—U.S. exports of superphosphates (acid phosphates), by countries

(Thousand short tons and thousand dollars)

Destination	1967		1968	
	Quantity	Value	Quantity	Value
Algeria	--------	--------	14	$473
Argentina	5	$206	7	314
Australia	2	139	9	385
Belgium-Luxembourg	--------	--------	58	1,660
Brazil	80	3,521	136	5,643
Burma	--------	--------	64	4,599
Canada	123	5,925	110	5,139
Chile	85	3,963	165	5,567
Colombia	12	708	44	1,942
Costa Rica	6	259	9	338
Dominican Republic	7	321	7	258
Ecuador	3	147	5	301
France	2	98	32	1,118
Germany, West	(1)	8	18	589
Indonesia	--------	--------	119	7,877
Italy	3	128	21	859
Jamaica	6	185	2	92
Japan	16	787	37	1,479
Korea, South	75	3,664	144	5,488
Malaysia	--------	--------	9	473
Mexico	15	791	25	1,054
Nansei and Nanpo Islands	4	164	3	100
Netherlands	113	4,971	87	3,325
Pakistan	151	7,631	84	3,784
Singapore	--------	--------	8	388
Turkey	--------	--------	11	427
United Kingdom	4	164	(1)	18
Uruguay	3	186	9	480
Venezuela	12	472	(1)	2
Yugoslavia	10	407	45	1,400
Other	6	294	12	792
Total	743	35,139	1,289	56,359

(1) Less than ½ unit.

Table 12.—U.S. imports for consumption of phosphate rock and phosphatic fertilizers

(Thousand short tons and thousand dollars)

Fertilizer	1967		1968	
	Quantity	Value	Quantity	Value
Phosphates, crude and apatite	139	$3,261	116	$2,679
Phosphatic fertilizers and fertilizer materials	105	6,167	44	2,222
Ammonium phosphates, used as fertilizers	212	17,720	247	17,264
Bone ash, bone dust, bone meal and bones, crude, steamed, or ground	7	395	5	357
Manures, including guano	(1)	7	(1)	16
Basic slag	(1)	15	--------	--------
Dicalcium phosphate	6	322	21	1,176

(1) Less than ½ unit.

WORLD REVIEW

Angola.—Phosphate rock deposits in the Cabinda district were recently estimated at 15 million tons and those in the Zaire district in northwestern Angola at 12 million tons.[4]

Australia.—Australia depends entirely upon imports for phosphate rock (3.26 million tons in 1967), but recent discoveries of this material in northwestern Queensland may soon change this situation. After the discovery of the Duchess deposits, near Duchess, by Broken Hill South, Ltd., in 1966, the search for phosphate was greatly increased, especially by this firm and International Minerals and

---

[4] Bureau of Mines. Mineral Trade Notes. V. 65. No. 4, April 1968, pp. 30–31.

Table 13.—World production of phosphate rock by countries

(Thousand short tons)

Country [1]	1964	1965	1966	1967	1968 p
North America:					
United States	25,715	r 29,482	39,044	39,770	41,251
Mexico	37	44	61	60	29
Netherlands Antilles [2]	r 122	r 130	r 162	128	103
South America:					
Brazil:					
Apatite (ores and concentrates)	215	211	325	e 331	e 331
Phosphate rock	56	96	92	e 88	e 94
Chile:					
Apatite	14	11	---------	---------	---------
Guano	17	24	17	18	24
Peru (guano)	226	187	61	72	e 83
Venezuela	---------	e 7	r e 7	33	66
Europe:					
Belgium	24	e 24	e 24	e 24	e 22
France (phosphatic chalk)	48	38	r 40	27	e 33
Poland	98	103	e 103	e 105	e 105
U.S.S.R.:					
Apatite (marketable concentrate 39 percent P_2O_5)	r [3] 7,033	r [3] 8,322	r e 8,818	e 9,700	[3] 10,692
Sedimentary rock (marketable concentrate 25 percent P_2O_5) e	4,800	6,670	7,440	8,270	8,820
Africa:					
Algeria	80	95	r 131	218	e 220
Morocco	11,131	10,830	10,405	10,962	11,857
Senegal:					
Aluminum phosphate	133	149	160	167	e 160
Calcium phosphate	746	956	1,091	1,229	e 1,102
Seychelles Islands (guano) [2]	4	7	4	4	e 4
South Africa, Republic of	638	672	1,172	1,490	1,726
Togo	829	1,065	1,228	1,238	1,515
Tunisia	3,032	3,351	r 3,545	3,097	3,796
Uganda (apatite)	r 192	r 216	r 188	162	e 157
United Arab Republic	676	654	728	753	e 1,588
Asia:					
China, mainland e	r 880	r 990	1,100	1,100	1,100
Christmas Island (Indian Ocean) [2]	868	828	1,065	1,113	1,247
India (apatite)	4	8	18	13	7
Indonesia	4	e 4	e 11	e 11	e 11
Israel	265	428	r e 717	e 661	856
Jordan	r 623	913	r 1,141	1,364	1,280
Korea, North (apatite) e	220	220	276	276	331
Vietnam, North:					
Apatite e	1,100	1,100	1,100	1,100	1,100
Phosphate rock e	55	55	55	55	55
Oceania:					
Australia	6	5	6	13	6
Makatea Island (French Oceania)	428	340	195	---------	---------
Nauru Island [2]	2,038	1,649	2,245	1,981	2,485
Ocean Island [2]	362	414	419	500	582
Total [4]	r 62,719	r 70,298	r 83,194	86,133	92,838

e Estimate. p Preliminary. r Revised.

[1] Small quantities of phosphate rock also produced in Cambodia, Colombia, Jamaica, Philippines, Southern Rhodesia, and Tanzania; guano in territory of South-West Africa, Argentina and the Philippines.

[2] Exports.

[3] Reported in Soviet sources.

[4] Total is of listed figures only.

Chemical Corp. (IMC) and Continental Oil Co., which have permits to prospect large areas of land in northwestern Queensland and the adjoining area in Northern Territory. Broken Hill South, Ltd., recently reported reserves of 1.1 billion tons of phosphate rock at Duchess and 250 million tons at Lady Annie, east of Camooweal, having a cutoff grade of 18 percent P_2O_5. Some of the rock is higher grade. IMC and Continental Oil have both reported phosphate rock deposits in the Yelvertoft area, between Mount Isa and Camooweal, but complete information was not available. IMC revealed in 1967 that deposits in the Yelvertoft area may contain 500 million tons of rock containing 16 percent P_2O_5. Continued investigations by the firms are likely to show billions of tons of phosphate reserves in Australia. Their commercial attractiveness will depend on grade, tonnage, overburden, locality, and ease of beneficiation.[5]

Belgium.—Occidental Petroleum Corp. contracted to build a new superphosphoric acid plant for Societa de Prayon S.A. at its plant in Engis, Belgium. The Occidental–Nordac process will be used.

Morocco.—Phosphate rock reserves in Morocco were estimated at 44 billion tons. The phosphate rock industry is nationalized under the control of Maroc–Chemie which is controlled by the Office Cherifien des Phosphates. By 1972, the output is expected to reach 19.29 million tons—13.56 million tons from Khouribga, 3.75 million tons from Youssoufia, and 1.98 million tons from Ben Guerir. Morocco's phosphate industry is concentrated around the port of Safi, where 386,000 tons of phosphate is converted annually to triple superphosphate containing 45 to 48 percent P_2O_5. A recent plan to erect a plant to produce 386,000 tons of superphosphoric acid annually at Casablanca in participation with Occidental Petroleum Corp. of Los Angeles was abandoned.[6]

Nauru.—Nauru, Ocean Island, and Christmas Island reportedly still have significant reserves of phosphate ore despite having been worked for phosphate for more than 60 years. The British Phosphate Commission (BPC), consisting of commissioners from the United Kingdom, Australia, and New Zealand, have operated the Nauru and Ocean Island deposits since 1920 and managed the Christmas Island deposits since 1948. BPC has supplied the total phosphate requirements of Australia and New Zealand since 1920. The strong possibility that Australia may soon obtain domestic phosphate from discoveries in Queensland presents new problems of marketing phosphate rock from the islands, but the outlook is optimistic.[7]

U.S.S.R.—A new deposit of apatite was found in the Khibiny area in the Kola Peninsula about 75 miles from the ice-free port of Murmansk. The deposit was reportedly shallow and about 2 miles long. Mines in the Kola Peninsula currently produce 10 million tons of apatite concentrate annually, containing 38 to 39 percent P_2O_5.[8]

United Arab Republic.—Government authorities set aside considerable funds for developing Egypt's phosphate reserves. During 1968/1969, more than $6.75 million was spent in developing deposits on the eastern coast, which contain 500 million tons of phosphate rock. Work also was to start on deposits between the Nile Valley and New Green Valley and in the Kharga and Dakhla Oases.[9]

TECHNOLOGY

The use of draglines in open-pit phosphate rock mining operations in the United States, Morocco, and Senegal was described.[10] The report also listed numerous available draglines by manufacturer and specifications, such as bucket capacity, boom length, tub diameter, and working weight. The world's largest phosphate mining dragline is in use in North Carolina. This machine, costing about $6 million, weighs 4,440 tons and has a 300-foot boom and a 72-cubic-yard bucket.

The new Kellogg-Lopker process for producing phosphoric acid reportedly could cut costs by as much as 15 percent.[11] The process, invented by Edwin B. Lopker and acquired by The M. W. Kellogg Co., a division of Pullman, Inc., was tested for more than a year in a 60-ton-per-day pilot plant. As a result of successful tests, a new plant having a capacity of 240 tons per day was to be constructed.

A wet process jointly developed by Lummus Co. and Japan's Nippon Kokan (NKK) was reported to yield 40 to 42 percent P_2O_5 phosphoric acid directly and calcium sulfate hemihydrate.[12] The latter, when further hydrated, forms high-quality gypsum usable for wall board or cement clinker. Conventional processes yield 28 to 32 percent acid and dihydrate gypsum crystals. Some of the features of the new hemihydrate method promise astonishing savings in capital investment, power consumption, and reaction time. The efficiency of the process was reported at 98 percent. The two firms experimented with the process on a near-commercial scale at Koyazu, Japan, and the output reached a rate of 35 metric tons per day for brief periods of time. The new process was reported to be quite similar to a Dorr-Oliver process developed for a plant under construction in Finland, which will produce 42 to 45 percent P_2O_5 acid and hemihydrate calcium sulfate crystals.

---

[5] Noakes, L. C., and Z. Kalix. Phosphate Rock in Australia. Australian Miner. Ind., Part 1, Quart. Rev., v. 21, No. 2, December 1968, pp. 34–38.

[6] Bureau of Mines. Mineral Trade Notes. V. 65, No. 6, June 1968, pp. 17–19.

[7] Industrial Minerals (London). Future of the Phosphate Islands. No. 13, October 1968, pp. 32–33.

[8] Industrial Minerals (London). More Apatite Found in Kola Area. No. 5, February 1968, p. 30.

[9] European Chemical News (London). Egypt Develops Phosphate Finds. V. 14, No. 350, Oct. 18, 1968, p. 12.

[10] Phosphorus and Potassium. Mining Phosphate Rock With Dragline Excavators. No. 35, May–June 1968, pp. 22–29.

[11] Farm Chemicals. What's Doing in Industry: A New Process. V. 131, No. 6, June 1968, p. 136.

The world's first of two planned ships for transporting liquid phosphorus was launched in April.[13] The Albright Pioneer was built in England to transport 5,000-ton cargoes of liquid phosphorus from Albright & Wilson, Ltd.'s, new $44 million phosphorus plant under construction at Long Harbour, Newfoundland, to various parts of the world. The hazards of phosphorus solidification at normal temperatures and upon exposure to air were overcome by special equipment designed to keep the element at 60° C during shipping and pumping operations.

A chemical method for removing phosphates from municipal and industrial waste water was developed. The addition of metal ions to the waste water converts soluble phosphates to an insoluble form.[14]

---

[12] Chemical Engineering. Chementator—Yet Another Wet Process for High-Strength Phosphoric Acid Is Ready for Licensing. V. 75, No. 19, Sept. 9, 1968, p. 42.

[13] European Chemical News. World's First Phosphorus Ship Is Launched. V. 13, No. 325, Apr. 26, 1968, p. 42.

[14] Minerals Processing. Dow Chemical Process Removes Phosphates. V. 9, No. 3, March 1968, p. 5.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/10

Platinum-Group Metals

By J. Patrick Ryan [1]

The platinum-group metals industry in 1968 was marked by a continued short supply of platinum and a high degree of speculative activity resulting in a wide gap between producers' and dealers' prices. Prices trended upward for platinum, but dealer's palladium prices generally moved down, reflecting an ample supply situation for the latter metal. The domestic supply and prices of the major platinum-group metals continued to be determined to large extent by the selling policy of the U.S.S.R., the leading producer.

Indicated industrial consumption of platinum-group metals, based on sales, increased slightly; industry stocks were less than those at yearend 1967.

The copper industry strike, which continued through the first quarter, again reduced domestic production of platinum-group metals.

World output of platinum-group metals continued to expand for the sixth consecutive year.

Legislation and Government Programs.—The Government added about 93,600 ounces of palladium to its stockpile of strategic and critical materials under its 200,060-ounce palladium contract. On December 19 the Government contracted for 2,238 ounces of iridium for delivery by June 30, 1969. Payment for the iridium will be made with 9,200 ounces of ruthenium sponge which has been authorized for disposal from the stockpile.

On June 17, a contract was let for refining 7,980 ounces of excess subspecification grade palladium, payment for services performed to be made in excess materials from the stockpile.

Legislation was introduced in the Congress for the release of 115,000 ounces of excess platinum from the national stockpile, but enactment of the bill (H.R. 5789) was held in abeyance pending approval of amendments and further consideration before the House Armed Services Committee.

Table 1.—Salient platinum-group metals statistics

(Troy ounces)

	1964	1965	1966	1967	1968
United States:					
Mine production [1]	40,487	35,026	51,423	16,365	14,793
Value thousands	$2,396	$2,041	$3,107	$1,429	$1,501
Refinery production:					
New metal	71,090	61,723	73,615	29,663	12,305
Secondary metal	120,147	108,525	103,321	365,799	329,455
Exports (except manufactures)	146,306	103,097	205,456	279,852	395,157
Imports for consumption	882,705	1,172,643	1,352,256	1,321,278	1,772,119
Stocks Dec. 31: Refiner, importer, dealer	767,264	926,373	1,129,604	869,211	802,711
Consumption	1,117,680	1,186,701	1,675,795	1,334,296	1,367,911
World: Production	2,545,761	2,968,885	3,055,098	3,169,720	3,415,325

[1] From crude platinum placers and byproduct platinum-group metals recovered largely from domestic gold and copper ores.

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Government inventory of platinum-group metals, December 31, 1968

(Troy ounces)

Metal	National stockpile	Supplemental stockpile	Objective	
			Conventional war	Nuclear war
Iridium	[1] 13,397	----------	17,000	3,100
Palladium	[2] 294,439	747,680	1,300,000	630,000
Platinum	[3] 400,077	49,999	335,000	235,500
Ruthenium	----------	11,699	----------	----------

[1] Excludes 184 ounces nonstockpile grade.
[2] Excludes 6,394 ounces nonstockpile grade.
[3] Excludes 36 ounces nonstockpile grade.

DOMESTIC PRODUCTION

Refinery production of new metal continued to decline for the second consecutive year, largely because of the effects of the copper strike that closed major copper refineries during parts of 1967 and 1968. Output of primary metals was nearly 60 percent less than that in 1967; recovery of secondary metals declined about 10 percent. Most of the domestic production was recovered as a byproduct of copper refining, but a significant part of the total output came from Alaska placers.

Toll refining of platinum-group metals increased 16 percent in 1968 to a total of 2,337,100 ounces, of which 2,135,200 ounces or 91 percent was from used materials and the remaining 201,900 ounces from virgin material. With the exception of platinum, all metals showed an increase in the amount refined on toll: Platinum decreased 3 percent to 1,184,590 ounces; palladium increased 49 percent to 1,055,470 ounces; and rhodium refining was up 6 percent to 73,350 ounces. The quantities of iridium, osmium, and ruthenium toll refined increased sharply in 1968 to 11,810, 2,920, and 9,020 ounces, respectively.

Table 3.—New platinum-group metals recovered by refiners in the United States by sources

(Troy ounces)

Year and source	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1964	30,539	27,301	3,981	515	6,274	2,480	71,090
1965	25,247	26,339	2,628	1,199	4,858	1,452	61,723
1966	30,048	31,367	3,979	1,533	5,650	1,038	73,615
1967:							
Domestic sources: Crude platinum; gold and copper refining	6,736	8,142	754	151	57	11	15,851
Foreign crude platinum	13,560	120	------	------	132	------	13,812
Total	20,296	8,262	754	151	189	11	29,663
1968:							
Domestic sources: Crude platinum; gold and copper refining	4,816	5,275	454	95	36	6	10,682
Foreign crude platinum	1,486	83	------	------	54	------	1,623
Total	6,302	5,358	454	95	90	6	12,305

Table 4.—Secondary platinum-group metals recovered in the United States

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1964	66,043	49,879	764	928	2,338	195	120,147
1965	53,562	50,025	960	763	2,590	625	108,525
1966	49,563	50,009	402	728	2,434	185	103,321
1967	126,377	215,162	7,748	2,377	11,505	2,680	365,799
1968	115,587	195,620	2,127	672	12,176	3,278	329,455

CONSUMPTION AND USES

Consumption of all platinum-group metals, as indicated by sales to consuming industries, increased slightly in 1968 compared with the 1967 total. Platinum sales, reflecting a tight supply situation, were down 8 percent due largely to the falloff in shipments to petroleum refiners, but palladium sales were up 16 percent, more than offsetting the decline in platinum sales. Rhodium sales declined 19 percent; sales of iridium and osmium dropped 22 and 12 percent, respectively, while ruthenium remained about the same.

As in several preceding years, the chemical, petroleum, and electrical industries continued to use most of the platinum-group metals, accounting for about 77 percent of the total sold in 1968 compared with 80 percent of the total in 1967.

In 1968, 28 percent of the total platinum sold went to petroleum refiners, 27 percent to manufacturers of organic and inorganic chemicals, and 20 percent to electrical and electronic equipment manufacturers. Of the total palladium sold, 46 percent went to electrical equipment manufacturers, and 32 percent to chemical manufacturers. The minor platinum-group metals, rhodium, iridium, and ruthenium, were used largely for alloying with platinum and palladium.

In the electrical industry, the largest consumer of platinum-group metals, the major application was palladium for electrical contacts in telephone equipment; platinum was used largely for aircraft engine spark plugs (electrode tips), thermocouples, magnets, and electrodeposited printed circuits. Small amounts of platinum also were used in fuel cell electrodes. New developments in this field could lead to a substantial increase in platinum requirements. Increased quantities of platinum and palladium powder (paste) were used in miniaturized electronic circuits. Significant quantities of platinum were used in impressed current corrosion protection systems.

The chemical industry used platinum and palladium as catalytic materials primarily in the production of nitric acid for fertilizers and explosives, catalysts for the manufacture of pharmaceuticals and vitamins, and in laboratory ware. A small but growing use of platinum and palladium was in catalytic air pollution control systems. in the chemical industry and in exhaust abatement mufflers for diesel trucks and buses.

The petroleum industry used large quantities of platinum for reforming of naphthas to improve octane ratings of gasoline and for hydrocarbon synthesis to produce numerous petrochemicals.

In the fiberglass industry a substantial quantity of platinum-rhodium alloy was used for bushings for attenuating the glass fibers and for equipment used in manufacturing other glass products.

Engelhard Minerals & Chemical Corp. reported the development of new markets that are likely to expand the use of platinum-group metals in various industrial products and space equipment. Engelhard's new exhaust eliminator, known as the PTX–D Purifier, tested on diesel-powered fork-lift trucks and mining machinery, showed consistent oxidation of contaminants. The success of the PTX–D Purifier lies in its platinum-group metal catalyst which oxidizes carbon monoxide, hydrocarbons and exhaust odors into harmless carbon dioxide and water. The units can also be designed for use on white gasoline or liquefied petroleum gas fueled vehicles.

A precious metal-crated titanium anode developed by the company may replace graphite anodes in the chloride manufacturing industry.

Table 5.—Platinum-group metals sold to consuming industries in the United States

(Troy ounces)

Year and industry	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1964	451,350	591,432	9,652	1,379	55,426	8,441	1,117,680
1965	411,435	717,085	9,554	1,634	38,910	8,083	1,186,701
1966	690,787	894,212	10,993	1,836	69,688	8,279	1,675,795
1967:							
Chemical	159,384	192,011	4,610	823	17,770	4,984	379,582
Petroleum	245,560	3,506	514	--------	397	21	249,998
Glass	45,150	301	128	--------	11,281	8	56,868
Electrical	99,686	324,684	2,528	1	11,736	1,479	440,114
Dental and medical	24,630	56,085	195	871	77	315	82,173
Jewelry and decorative	33,342	18,676	2,685	--------	8,775	1,419	64,897
Miscellaneous	26,112	25,878	1,426	128	4,916	2,204	60,664
Total	633,864	621,141	12,086	1,823	54,952	10,430	1,334,296
1968:							
Chemical	157,677	228,318	2,047	907	14,507	3,037	406,493
Petroleum	161,050	22,683	565	1	201	4	184,504
Glass	47,935	10	11	--------	7,441	--------	55,397
Electrical	117,256	329,012	2,716	12	9,514	1,991	460,501
Dental and medical	24,903	61,636	390	533	38	371	87,871
Jewelry and decorative	40,184	17,797	2,998	50	7,059	3,568	71,656
Miscellaneous	31,150	62,023	716	109	6,016	1,475	101,489
Total	580,155	721,479	9,443	1,612	44,776	10,446	1,367,911

Table 6.—Refiner, importer, and dealer stocks of platinum-group metals in the United States, December 31

(Troy ounces)

Year	Platinum	Palladium	Iridium	Osmium	Rhodium	Ruthenium	Total
1964	378,896	317,691	20,022	1,936	38,388	10,331	767,264
1965	422,804	427,450	18,374	1,502	44,531	11,712	926,373
1966	459,669	574,651	20,677	2,559	57,737	14,311	1,129,604
1967	327,919	460,624	17,410	2,802	47,275	13,181	869,211
1968	322,932	393,882	15,127	2,402	55,097	13,271	802,711

STOCKS

During the year, stocks of platinum-group metals held by refiners and dealers declined collectively about 8 percent and were down individually as follows: platinum, 2 percent; palladium, 14 percent; iridium, 13 percent; and osmium, 14 percent. Inventories of rhodium and ruthenium increased 17 and 1 percent, respectively.

Yearend stocks of platinum and palladium held in storage by the Mercantile Exchange totaled 5,800 and 306,500 ounces, respectively.

PRICES

A salient feature of the platinum market was the extremely wide spread between prices quoted by producers for platinum and those quoted by dealers, reflecting a continuation of the tight supply situation. Average dealer prices were more than twice those of producers. Palladium prices were much more stable with a narrow spread between producers and dealers quotations reflecting an ample supply and less speculation. The uncertainity of the supply of platinum-group metals from the U.S.S.R. continued to be an important factor affecting their market price.

The producers price per ounce of platinum advanced from a range of $109 to $125 at the beginning of the year to $120 to $125 on July 1, remaining unchanged to the yearend. Dealers' 1968 quotations opened at $225, dropped to

$208 in February, then advanced to a high near midyear of $300, thereafter receding to a range of $275 to $285, and closing at $278. Producers' quotes for palladium rose from $37 to $39 on January 1 to $42 to $44 in mid-March, then to $45 to $47 on July 1, remaining unchanged thereafter. Dealers' quotations for palladium advanced from $42 on January 1 to a high of $56 in mid-March, dropping to $49 in May, advancing to $51 in June and declining thereafter to $42 in November through December. Producers' prices of the minor platinum-group metals remained virtually unchanged during the year as follows: Rhodium, $245 to $250; iridium, $185 to $190; osmium, $300 to $450; and ruthenium, $55 to $60 per ounce. Dealers' price quotations for rhodium ranged between $255 and $265 in the first half of the year, about $10 to $15 above the producers price; thereafter the dealers' price was virtually the same as the producers'. Similarly, the dealers' quote on iridium was slightly higher than the producers' price in the first half but declined after midyear to about the same level. Dealers' prices on osmium and ruthenium, virtually unchanged at $230 to $250 and $45, respectively, were below the corresponding producers' prices in the second half of the year.

FOREIGN TRADE

Exports of platinum-group metals, were up 41 percent in 1968, reaching a record high—nearly 395,200 ounces. Platinum comprised 56 percent of the total exported. Exports of palladium and other metals of the group (excluding platinum) increased 46 percent. West Germany received 30 percent of the total platinum-group metals exported, 17 percent went to the United Kingdom, 12 percent to Japan, and the remainder to 13 other countries.

Imports of platinum-group metals increased 34 percent in 1968 to a record high. Of the total metals imported, about 66 percent was palladium and 28 percent was platinum. The United Kingdom shipped about one-half of the total platinum-group metals imported, and 30 percent came from the Soviet Union; the remainder came chiefly from Western Europe and Canada.

Table 7.—U.S. exports of platinum-group metals, by countries

Year and destination	Platinum (ore, concentrates, waste and scrap, and platinum unworked or partly worked)		Palladium, rhodium, iridium, osmiridium, ruthenium, and osmium (unworked or partly worked, n.e.c.)	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1966	102,031	$13,414	103,425	$6,711
1967:				
Argentina	555	65	50	8
Australia	5	1	1,906	76
Belgium-Luxembourg	3,027	211	4,093	159
Brazil	362	26	1,653	108
Canada	6,087	623	4,799	243
Chile	252	23	50	2
Colombia	20	3	795	17
France	11,907	1,420	3,626	375
Germany, West	49,824	6,582	r 33,280	r 3,642
Hong Kong	711	117	34	1
India	24	4	232	33
Italy	16,408	1,819	16,019	874
Japan	17,646	2,832	19,600	1,451
Mexico	1,059	88	5,962	226
Netherlands	9,023	1,054	13,139	1,682
Spain	---------	---------	1,052	43
Switzerland	197	22	7,064	346
United Kingdom	44,189	4,338	4,067	456
Other	289	20	846	35
Total	161,585	19,248	r 118,267	r 9,772
1968:				
Argentina	7	1	1,258	54
Australia	---------	---------	3,230	146
Belgium-Luxembourg	30,961	1,622	2,647	85
Brazil	583	28	1,332	133
Canada	1,675	183	16,454	746
France	11,274	1,355	4,175	483
Germany, West	66,596	10,961	51,498	7,791
Hong Kong	---------	---------	664	33
Italy	12,006	1,410	16,562	1,500
Japan	21,928	4,581	26,898	2,515
Mexico	916	65	5,754	250
Netherlands	19,853	3,322	8,570	979
Netherlands Antilles	---------	---------	484	52
Spain	---------	---------	1,438	75
Switzerland	2,061	89	16,682	940
United Kingdom	54,973	7,356	13,786	2,711
Other	165	24	727	29
Total	222,998	30,997	172,159	18,522

r Revised.

Table 8.—U.S. imports for consumption of platinum-group metals

Year	Troy ounces	Value (thousands)
1966	1,352,256	$83,481
1967	r 1,321,278	r 92,120
1968	1,772,119	124,561

r Revised.

Table 9.—U.S. imports for consumption of platinum-group metals, by countries

Year and country	Unwrought											
	Grains and nuggets (platinum)		Sponge (platinum)		Sweepings, waste, and scrap		Iridium		Palladium		Rhodium	
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1967:[1]												
Australia	---	---	---	---	10,796	$1,153	---	---	---	---	128	$13
Belgium-Luxembourg	---	---	1,172	$168	2,312	221	---	---	547	$21	---	---
Canada	795	$125	4,952	868	25,016	1,867	5,600	$1,013	155,312	5,817	13,205	2,936
Colombia	24,987	3,044	2,780	399	2,377	81	---	---	---	---	---	---
France	---	---	---	---	2,100	172	---	---	3,862	145	---	---
Germany, West	---	---	552	60	---	---	200	38	14,112	537	299	63
Japan	641	111	---	---	1,660	199	---	---	---	---	---	---
Mexico	---	---	---	---	35,883	1,130	---	---	---	---	---	---
Netherlands	---	---	---	---	1,560	177	---	---	168,759	6,194	1,977	408
Norway	5,170	674	1,275	166	2,085	268	---	---	4,676	200	---	---
Panama	1,520	203	275	64	---	---	---	---	---	---	---	---
South Africa, Republic of	---	---	---	---	4,444	307	---	---	---	---	---	---
Sweden	---	---	---	---	7,878	725	---	---	---	---	---	---
Switzerland	---	---	6,657	996	---	---	---	---	35,100	1,334	50	10
U.S.S.R	1,585	254	1,585	255	---	---	---	---	111,248	4,339	15,029	3,121
United Kingdom	7,100	784	238,180	27,873	714	77	2,984	454	119,956	4,586	14,465	3,000
Other	---	---	275	30	5,242	503	---	---	97	4	---	---
Total	41,798	5,195	257,703	30,879	102,067	6,880	8,784	1,505	613,669	23,177	45,153	9,551
1968:												
Australia	---	---	---	---	9,447	1,107	---	---	---	---	---	---
Belgium-Luxembourg	---	---	1,651	209	6,021	538	---	---	2,830	137	9	1
Canada	6	1	1,947	178	18,907	1,047	2,000	380	78,550	3,067	16,270	3,646
Colombia	19,664	3,723	1,200	218	1,113	75	---	---	---	---	---	---
France	---	---	---	---	320	23	---	---	15,292	748	---	---
Germany, West	74	16	1,252	145	60	13	---	---	4,828	228	167	40
Japan	1,359	364	497	144	8	1	---	---	17,860	706	---	---
Mexico	542	119	---	---	3,703	81	---	---	494	59	---	---
Netherlands	---	---	701	161	154	27	---	---	63,017	2,713	326	81
Norway	3,950	895	2,200	535	---	---	---	---	4,410	193	---	---
South Africa, Republic of	---	---	---	---	3,195	224	---	---	---	---	---	---
Spain	---	---	---	---	---	---	---	---	10,669	437	---	---
Sweden	350	76	---	---	2,741	120	---	---	350	16	---	---
Switzerland	51	10	1,766	404	---	---	5	1	26,196	1,096	2,897	389
U.S.S.R	1,252	324	3,521	945	---	---	---	---	419,543	18,574	4,118	1,033
United Kingdom	36,327	4,419	288,826	32,921	1,737	203	3,498	637	424,556	18,616	17,239	3,678
Other	1,202	233	---	---	7,425	402	---	---	---	---	---	---
Total	64,777	10,180	303,561	35,860	54,831	3,861	5,503	1,018	1,068,595	46,590	41,026	8,868

See footnote at end of table.

Table 9.—U.S. imports for consumption of platinum-group metals, by countries—Continued

Year and country	Unwrought				Semimanufactured								Total	
	Ruthenium		Other platinum-group metals		Platinum		Palladium		Rhodium		Other platinum-group metals			
	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)	Troy ounces	Value (thuosands)	Troy ounces	Value (thousands)	Troy ounces	Value (thousands)
1967:[1]														
Australia	------	------	------	------	------	------	------	------	------	------	------	------	10,924	$1,166
Belgium-Luxembourg	------	------	------	------	------	------	1,183	$45	------	------	------	------	5,214	455
Canada	28,800	1,056	617	$183	75	$9	------	------	1,607	$319	------	------	235,979	14,193
Colombia	------	------	------	------	------	------	------	------	------	------	------	------	30,144	3,524
France	------	------	------	------	------	------	------	------	------	------	------	------	5,962	317
Germany, West	------	------	100	37	2,467	264	4,247	161	26	6	------	------	22,003	1,166
Japan	------	------	------	------	------	------	------	------	------	------	42	$2	2,343	312
Mexico	------	------	------	------	------	------	------	------	------	------	------	------	35,883	1,130
Netherlands	------	------	------	------	------	------	16,086	594	645	148	------	------	189,027	7,521
Norway	------	------	------	------	------	------	------	------	------	------	------	------	13,206	1,308
Panama	------	------	------	------	------	------	------	------	------	------	------	------	1,795	267
South Africa, Republic of	------	------	------	------	------	------	------	------	------	------	------	------	4,444	307
Sweden	------	------	------	------	------	------	------	------	------	------	------	------	7,878	725
Switzerland	------	------	------	------	272	28	------	------	------	------	------	------	42,079	2,868
U.S.S.R	------	------	------	------	468	76	78,081	2,679	------	------	------	------	207,996	10,724
United Kingdom	25,763	913	2,403	301	60,933	6,867	23,816	847	258	55	4,001	310	500,573	46,067
Other	------	------	214	33	------	------	------	------	------	------	------	------	5,828	570
Total	54,563	1,969	3,334	554	64,215	7,244	123,418	4,326	2,536	528	4,043	312	1,321,278	92,120
1968:														
Australia	------	------	------	------	80	17	------	------	------	------	------	------	9,527	1,124
Belgium-Luxembourg	------	------	110	16	------	------	------	------	------	------	------	------	10,621	901
Canada	3,800	140	10	1	1,589	193	828	38	3,000	65	208	6	127,115	8,762
Colombia	------	------	5,488	907	------	------	------	------	------	------	------	------	27,465	4,923
France	------	------	------	------	------	------	3,219	149	------	------	------	------	18,831	920
Germany, West	------	------	1,628	81	7,452	590	------	------	85	21	3,052	125	18,598	1,259
Japan	------	------	------	------	1,728	376	9,168	372	------	------	------	------	30,620	1,963
Mexico	------	------	------	------	105	20	87	4	------	------	------	------	4,931	283
Netherlands	------	------	25	5	7	1	4,970	231	------	------	------	------	69,200	3,219
Norway	------	------	------	------	1,200	202	200	8	------	------	------	------	11,960	1,833
South Africa, Republic of	------	------	3,548	634	------	------	------	------	------	------	------	------	6,743	858
Spain	------	------	------	------	------	------	------	------	------	------	------	------	10,669	437
Sweden	------	------	------	------	------	------	------	------	------	------	------	------	3,441	212
Switzerland	------	------	------	------	1,298	315	147	7	------	------	------	------	32,360	2,222
U.S.S.R	------	------	990	212	306	66	54,489	2,403	26,905	1,406	------	------	511,124	24,963
United Kingdom	7,362	314	9,923	1,737	54,912	6,392	23,808	1,032	------	------	2,099	98	870,287	70,047
Other	------	------	------	------	------	------	------	------	------	------	------	------	8,627	635
Total	11,162	454	21,722	3,593	68,677	8,172	96,916	4,244	29,990	1,492	5,359	229	1,772,119	124,561

[1] Revised to include sweepings, waste, and scrap.

WORLD REVIEW

World production of platinum-group metals increased 8 percent in 1968, the sixth consecutive annual gain and a record high output.

The three major producing countries, U.S.S.R., Republic of South Africa, and Canada, recorded moderate increases. U.S. production dropped for the second consecutive year, reflecting the effects of the copper strike. Output in Colombia showed an appreciable gain.

Canada.—Canadian production of platinum-group metals was 63,137 ounces more in 1968 than that in 1967. Virtually all of these metals were recovered as byproducts of nickel ores by The International Nickel Company of Canada Ltd. (INCO) and Falconbridge Nickel Mines, Ltd., mostly in the Sudbury district of Ontario. The platinum-rich slimes from INCO nickel refining operations was shipped to the company's precious metals refinery at Acton, England, for separation of the platinum-group metals. Falconbridge shipped nickel matte to its nickel refinery in Khristiansand, Norway. Platiniferous slimes from the nickel refinery were shipped to Engelhard Minerals & Chemical Corp. in Newark, N.J., for separation of metals.

Colombia.—Output of platinum and associated metals increased nearly 21 percent in 1968. International Mining Corp., the largest producer of platinum, reported that it recovered 13,049 ounces of platinum from 15.5 million cubic yards of placer gravels dredged in the Choco and Narino areas. Dredging reserves totaled 163.7 million cubic yards with an average value of 18.8 cents per cubic yard compared with 173.2 million yards averaging 17.2 cents in 1967. The company reported that an additional small dredge began operations in the San Juan river basin in August and another small dredge is scheduled to start operation in Narino in mid-1969.

South Africa, Republic of.—The expansion in output of platinum-group metals continued for the sixth consecutive year in 1968 with a gain of 9 percent over 1967 output. Nearly all the platinum-group metals were produced from platinum ores, but a small amount of osmiridium was recovered as a byproduct from gold ores.

Rustenburg Platinum Mines, Ltd., continued to increase productive capacity at its mines. In 1968 the company expanded its plant facilities to produce 850,000 ounces of platinum annually by late 1969

Table 10.—World production of platinum-group metals

(Troy ounces)

Country	1964	1965	1966	1967	1968 [p]
North America:[1]					
Canada: Platinum and platinum group metals	376,238	463,127	396,059	401,263	464,400
United States: Placer platinum and from domestic gold and copper refining	40,487	35,026	51,423	16,365	14,793
South America:[1] Colombia:					
Placer platinum	20,647	11,141	[r] 15,671	12,411	15,076
Europe: U.S.S.R.:					
Placer platinum and from platinum-nickel-copper ores [e]	1,500,000	1,700,000	1,800,000	1,900,000	2,000,000
Africa:					
Ethiopia: Placer platinum	[e] 180	353	318	282	[e] 250
South Africa, Republic of:					
Platinum-group metals from platinum ores [e]	600,000	750,000	780,000	825,000	900,000
Osmiridium from gold ores	[2] 4,135	[2] 3,820	[2] [e] 3,400	[e] 8,000	[e] 14,000
Asia:					
Japan:					
Palladium from refineries	1,875	2,952	5,494	3,327	4,034
Platinum from refineries	2,199	2,466	2,733	3,072	2,772
Total [3]	[r] 2,545,761	[r] 2,968,885	[r] 3,055,098	3,169,720	3,415,325

[e] Estimate. [p] Preliminary. [r] Revised.

[1] U.S. imports include platinum from other Western Hemisphere countries which are not listed as producers.

[2] Sales.

[3] Total is of listed figures only.

and plans further increases to 950,000 ounces by early 1970 and 1 million ounces by the latter half of 1970. Rustenburg believes that its latest expansion will bring the platinum supply and demand into balance by mid 1970.

Union Corp., Ltd., reported the development of an improved process for treating osmiridium obtained from its Evander gold ores that will increase production of osmiridium and enable the osmiridium to be processed in South Africa instead of being exported for refining.

Union Corp. plans to construct a second refinery at East Geduld to process platinum and associated metals produced at the Bafokeng Mine of Impala Platinum Ltd. near Rustenburg. The platinum refinery will produce both base and platinum-group metals and will be entirely separate from the osmiridium refinery treating the concentrate produced as a byproduct of gold.

The Bafokeng Mine of Impala Platinum Ltd. was being opened by three pairs of inclined shafts, and lateral development at yearend was proceeding at a rate of 7,500 feet per month. Ore milling was scheduled to commence in January 1969 and smelting and refining operations by mid-1969. Initial production, at an annual rate of 100,000 ounces of refined platinum, is scheduled to begin near the end of 1969. Besides associated metals of the platinum group, the mine will also produce substantial quantities of byproduct nickel and copper.

TECHNOLOGY

The principal applications of the platinum-group metals were in industries that are highly research oriented. Research and development continued as a major effort during the year to improve process technology and develop new products. Extensive research to broaden the use of catalysts in the petroleum, petrochemical, chemical, and pharmaceutical industries was particularly noteworthy.

Universal Oil Products Corp. (UOP) developed a new platinum reforming catalyst (R–16) which improves efficiency in the use of platinum in producing high-octane, lead-free gasoline.

The R–16 catalyst used as a drop-in replacement in the UOP platforming process at several oil refineries is reported to (1) improve operation stability, and (2) provide higher yields of fuel, and larger, more uniform quantities of byproduct hydrogen at no additional cost. Refiners using R–16 produce more desulfurized fuel products compatible with catalytic mufflers for engine exhausts.

A rhenium-platinum reforming catalyst developed by Chevron Research is reported to be twice as efficient as the best conventional catalysts, giving higher product yield on lower capital investment. A test installation using the catalyst operated for 20 months before requiring regeneration, with no falloff in yield. The catalyst, consisting of a mixture of rhenium and platinum supported on alumina, could significantly reduce the petroleum industry's demand for new platinum.[2]

Engelhard Minerals & Chemicals Corp. also reported the development of a new platinum catalytic process for gasoline reforming called Magnaforming. Test runs at a large reforming plant indicated that the new process may effect substantial economy in producing high-octane gasoline compared to yields obtained from conventional methods at the same rate of output.

The Atomic Energy Commission (AEC) announced the development of a laboratory-scale ion-exchange separation process for recovering palladium and rhodium from atomic wastes which remain after the primary elements plutonium and uranium have been separated out of the nuclear reactor fuels. The AEC emphasized the need for scaling up the process to commercial levels and to work out the economics involved. The AEC also sought expressions of private interests in providing the additional facilities needed to separate palladium, rhodium, and technetium on a commercial scale from the waste fractions it can furnish. With the expansion of nuclear power anticipated in future years, fission waste products may constitute a significant source of supply of the platinum-group metals, ruthenium, rhodium, and palladium.

---

[2] Metals Week. May 5, 1969, p. 18.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/27

Potash

By Donald E. Eilertsen [1]

World potash production and U.S. potash consumption, imports, and exports continued to establish new high records. Domestic output, however, faced by keen competition from imports, continued to slump the peak production of 1966 to the smallest output since 1962. Canada led the free world in potash output for the first time.

Legislation and Government Programs.—Complaints filed with the Treasury Department in 1967 alleging that potassium muriate from Canada, West Germany, and France was being sold in the United States at less than fair value within the meaning of the Antidumping Act of 1921, as amended, continued under investigation. On June 18, Customs Officers were directed to withhold appraïsement of potassium muriate imported from these countries and at yearend the investigations were still under way.

Table 1.—Salient potash statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Production of potassium salts, marketable	4,954	5,401	5,701	5,649	4,769
Approximate K_2O equivalent	2,897	3,140	3,320	3,299	2,722
Value	$114,095	$129,767	$122,210	$105,313	$75,664
Sales of potassium salts by producers	5,201	5,027	5,377	5,363	5,091
Approximate K_2O equivalent	3,045	2,931	3,133	3,126	2,913
Value at plant	$120,284	$121,161	$116,340	$100,566	$81,620
Average value per ton	$23.13	$24.10	$21.64	$18.75	$16.03
Imports for consumption of potash materials	1,254	1,867	2,544	2,929	3,672
Approximate K_2O equivalent	737	1,108	1,491	1,708	2,179
Value	$35,797	$52,675	$71,821	$73,649	$78,573
Exports of potash materials	1,048	1,099	1,053	1,175	1,373
Approximate K_2O equivalent	618	648	621	693	810
Value	$37,586	$42,494	$38,159	$39,896	$44,724
Apparent consumption of potassium salts [1]	5,407	5,795	6,868	7,117	7,390
Approximate K_2O equivalent	3,164	3,391	4,003	4,141	4,282
World: Production, marketable:					
Approximate K_2O equivalent	13,415	15,128	16,059	16,858	17,140

[1] Measured by sold plus imports minus exports.

DOMESTIC PRODUCTION

Marketable production of potassium salts, in terms of potassium monoxide (K_2O) equivalent, was 17.5 percent less than in 1967 and 18 percent less than the record output of 1966. Although New Mexico output continued to decline, the State accounted for 84.1 percent of the total 1968 output. The average grade of New Mexico's production of crude potassium salts was 17.8 percent K_2O, compared with 18.2 percent in 1967. The drop in domestic potash production from 1967 to 1968 was largely attributed to larger imports of potassium muriate from Canada.

Eleven firms in five States produced potash raw materials. They were Duval Corp.; International Minerals & Chemical Corp., (IMC); Kermac Potash Co.;

---

[1] Physical scientist, Division of Mineral Studies.

National Potash Co.; Potash Company of America; Southwest Potash Corp.; United States Potash & Chemical Co. (from mines in New Mexico); American Potash & Chemical Corp. (from brine in California); Marquette Cement Manufacturing Co. (as byproduct in the manufacture of cement in Maryland); The Dow Chemical Co. (from brine in Michigan); and Texas Gulf Sulphur Co. (from operations in Utah).

In August, United States Borax & Chemical Corp. sold its potash properties in New Mexico which had been idle for 9 months, to Continental American Royalty Co. The new owner's subsidiary, United States Potash & Chemical Co., reactivated the operation shortly after the sale.

Table 2.—Production and sales of marketable potassium salts in the United States in 1968, by product

(Thousand short tons and thousand dollars)

Product	Production			Sales		
	Gross weight	K_2O equivalent	Value [1]	Gross weight	K_2O equivalent	Value
Muriate of potash, 60 percent K_2O minimum:						
Standard	1,732	1,059	$23,035	1,799	1,103	$23,550
Coarse	1,255	764	19,102	1,423	868	21,744
Granular	757	458	12,048	791	479	12,727
Total	3,744	2,282	54,186	4,013	2,449	58,021
Other potassium salts [2]	1,025	439	21,478	1,078	463	23,599
Grand total	4,769	2,722	75,664	5,091	2,913	81,620

[1] Derived from reported value of "Sold or used."

[2] Figures for refined muriate and manure salts are included with potassium sulfate and potassium-magnesium sulfate to avoid disclosing individual company confidential data. Includes sulfate manufactured from captive production of muriate.

Table 3.—Production and sales of potassium salts in New Mexico

(Thousand short tons and thousand dollars)

Year	Crude salts [1]		Marketable potassium salts					
	Mine production		Production			Sales		
	Gross weight	K_2O equivalent	Gross weight	K_2O equivalent	Value [2]	Gross weight	K_2O equivalent	Value
1964	17,356	3,122	4,585	2,675	$104,861	4,815	2,814	$110,772
1965	18,557	3,363	4,919	2,848	117,771	4,607	2,677	110,424
1966	20,105	3,528	5,096	2,953	108,653	4,872	2,827	104,668
1967	18,906	3,434	4,950	2,883	91,098	4,797	2,784	88,788
1968	14,382	2,564	4,051	2,289	63,406	4,425	2,511	70,198

[1] Sylvite and langbeinite.

[2] Derived from reported value of "Sold or used."

CONSUMPTION AND USES

The apparent consumption of potassium salts in the United States, measured by sales plus imports minus exports exceeded 7 million short tons for the second consecutive year and established the 21st new record in the past 25 years.

Deliveries of potash, both domestic and imported, for agricultural and chemical uses were the largest ever reported. Agricultural deliveries amounted to 94.5 percent of the total. The largest deliveries of agricultural potash, amounting to 36.6 percent of the total, were made to Illinois, Iowa, Indiana, and Ohio. New York was again the leading recipient of potash delivered for chemical usage.

Table 4.—Deliveries of potash salts in 1968, by States of destination

(Short tons K_2O equivalent)

Destination	Agricultural potash	Chemical potash
Alabama	115,214	24,206
Alaska	94	-------
Arizona	916	19
Arkansas	81,155	672
California	46,191	12,949
Colorado	7,343	163
Connecticut	2,936	375
Delaware	14,707	11,970
District of Columbia	383	-------
Florida	218,200	973
Georgia	198,782	365
Hawaii	23,151	-------
Idaho	6,261	-------
Illinois	543,843	26,950
Indiana	308,613	5,087
Iowa	327,566	900
Kansas	27,842	1,007
Kentucky	65,928	16,869
Louisiana	47,211	659
Maine	18,509	105
Maryland	73,564	1,934
Massachusetts	2,618	551
Michigan	107,871	2,709
Minnesota	211,259	565
Mississippi	92,497	494
Missouri	170,819	1,313
Montana	2,365	-------
Nebraska	34,731	517
Nevada	152	1,098
New Hampshire	185	68
New Jersey	15,615	2,508
New Mexico	5,557	1,170
New York	36,759	84,388
North Carolina	126,896	53
North Dakota	8,633	22
Ohio	276,061	8,085
Oklahoma	15,991	220
Oregon	11,800	847
Pennsylvania	37,259	4,354
Rhode Island	1,596	649
South Carolina	113,909	156
South Dakota	5,838	13
Tennessee	94,858	114
Texas	176,289	8,684
Utah	1,188	72
Vermont	101,548	8
Virginia	4,384	200
Washington	19,152	2,846
West Virginia	3,825	6,156
Wisconsin	166,866	111
Wyoming	1,019	-------
Total	3,975,949	233,174

Source: American Potash Institute, Atlanta, Ga.

STOCKS

Producers yearend stocks of potassium salts were 21.7 percent less than the all-time high set in 1967. Yearend stocks of imported potash were not available.

Table 5.—Producers' stocks of potassium salts in the United States

(Thousand short tons)

Year	Number of producers	Stocks, Dec. 31	
		Gross weight	K_2O equivalent
1964	10	519	295
1965	12	892	504
1966	12	1,215	690
1967	12	1,501	863
1968	13	1,175	676

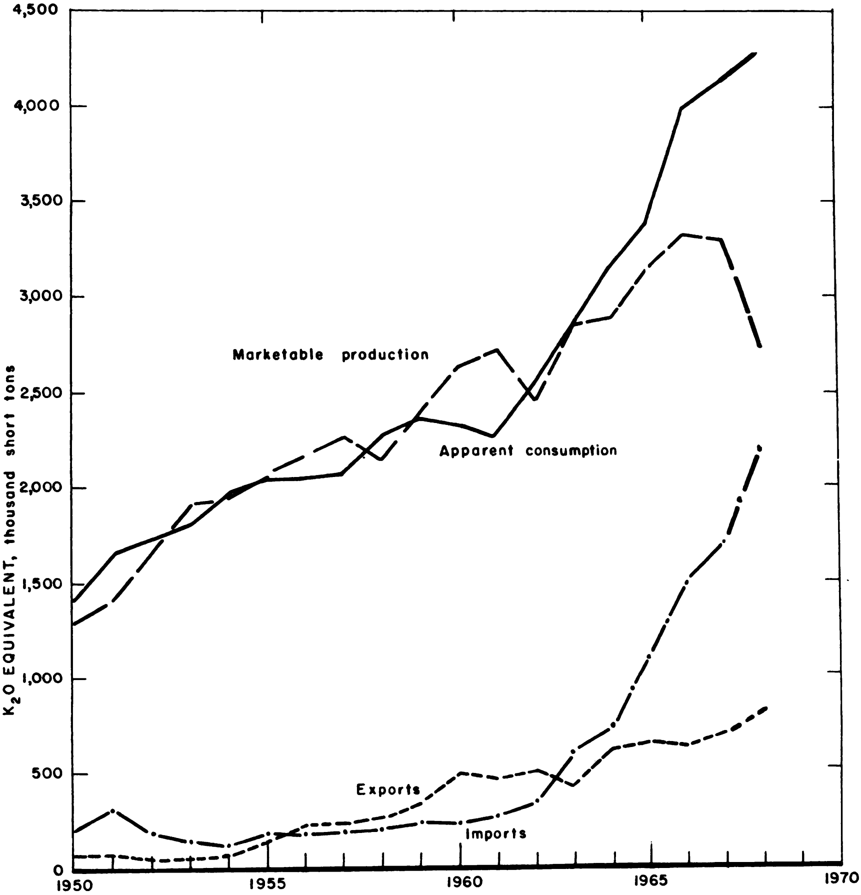

Figure 1.—Marketable production, apparent consumption, exports, and imports, K_2O equivalent.

PRICES

The published prices of potassium muriate and potassium sulfate are shown in table 6. In general, prices of standard, coarse, and granular potassium muriate were substantially smaller during the first 7 months of 1968 than those for the same period of 1967. However, prices were higher during the last 5 months of 1968 than those in 1967.

Table 6.—Prices for potassium products[1]

Product	Jan. 1-Feb. 16	Feb. 17-Aug. 2	Aug. 3-Dec. 31
Potassium chloride, chemical grade (95 to 99 percent KCl), per short ton	\$28.00	\$28.00	\$28.00
Potassium muriate, per unit-ton: [2]			
Standard (60 percent K_2O minimum)	.28	.30	.30 to .38
Coarse	.31	.33	.33 to .42
Granular	.34½	.36½	.36½
Potassium sulfate (per unit-ton): [2]			
Agricultural (minimum 50 percent K_2O)	[3].75	[4].80	.60
Granular	[3].85	[4].90	.68

[1] Bulk, carlots, works.
[2] 20 pounds of equivalent K_2O.
[3] Until Feb. 2, 1968.
[4] Until Sept. 13, 1968.
Source: Oil, Paint and Drug Reporter.

Table 7.—Bulk prices for potash[1]

(Cents per unit K_2O)

Product	1968			1969	
	Jan.	Feb.-May	July-Dec.	Jan.	Feb.-June
Muriate, 60 percent K_2O minimum:					
Standard	28	30	29	29	22
Coarse	31	33.5	33	33	25
Granular	34.5	36.5	35	35	27
Sulfate of potash, 50 percent K_2O minimum:					
Standard	75	80	70	70	75
Mine run salts, 20 percent K_2O minimum	17.65	17.65	17.65	17.65	17.65

[1] Carlots, f.o.b. cars Carlsbad, N. Mex., or Potasco, Saskatchewan, Canada.
Source: Potash Company of America, Division of Ideal Basic Industries, Inc.

Table 8.—Bulk prices for California potash[1]

(Cents per unit K_2O)

Product	1968				1969	
	Jan.	Feb.-May	June-Sept.	Oct.-Dec.	Jan.	Feb.-May
Muriate, 60 percent K_2O minimum:						
Standard	42	44	38	40	40	43
Coarse	47	49	42	44	44	47
Sulfate, 52 percent K_2O minimum:						
Standard	85	90	78	83	83	88
Granular	99	104	86	91	91	96

[1] Quoted by American Potash & Chemical Corp., carlots, f.o.b. Trona, Calif., for season of June 1, 1967, through May 31, 1968, on price lists of June 1, 1967; and for season of June 1, 1968, through May 31, 1969, on price lists of June 1, 1968.

FOREIGN TRADE

The export of potash fertilizer materials exceeded all previous records, and chemical potash exports were next to the record amount. Japan, South Korea, and Australia received 49 percent of the total fertilizer exports; South Korea and Canada received 54 percent of the chemical exports.

Imports of potash fertilizer materials exceeded previous records, and chemical potash imports were among the largest on record. Ninety percent of all potassium muriate imports (3.2 million short tons) were from Canada.

Table 9.—U.S. exports of potash materials, by countries

Destination	Fertilizer				Chemical			
	1967		1968		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	3,861	$128	5,600	$159	479	$119	1,731	$310
Australia	101,216	3,078	100,909	2,816	664	195	633	171
Belgium-Luxembourg	683	33	28,579	1,019	187	103	61	24
Brazil	39,235	946	82,483	2,191	1,051	236	1,707	369
Canada	64,722	2,496	73,243	2,750	8,744	1,468	7,459	1,373
Chile	16,116	454	18,592	543	236	24	71	17
Colombia	21,980	825	23,803	784	76	34	50	17
Costa Rica	19,120	571	25,698	597	4	2	622	26
Denmark	50	2	56	2	579	128	726	156
Dominican Republic	3,025	100	8,016	288	5	3	9	3
Ecuador	5,126	174	5,845	219	9	2	56	37
El Salvador	81	7	2,960	62	7	17	28	18
France	148	5	2,688	39	854	188	518	110
Germany, West	14,011	706	10,706	434	1,621	491	1,886	616
Honduras	5,020	179	6,395	192	19	5	10	4
India	49,732	1,727	26,128	1,165	407	94	483	113
Italy	319	11	93	2	1,371	311	727	153
Jamaica	15,563	422	13,476	291	19	15	29	12
Japan	428,317	13,349	422,769	12,751	11	11	857	75
Korea, South	111,300	2,811	132,388	3,035	------	------	10,582	366
Leeward and Windward Islands	3,856	111	3,196	88	2	(1)	1	(1)
Mexico	44,791	1,211	55,486	1,334	1,322	251	1,344	271
Netherlands	---------	------	33,207	660	530	206	179	42
Netherlands Antilles	4,408	133	26	1	3	5	3	1
New Zealand	36,274	1,298	32,650	1,179	72	17	59	22
Pakistan	11,262	299	38,602	1,552	3	15	383	77
Peru	3,084	126	3,708	165	45	27	126	51
Philippines	21,675	513	21,584	511	85	52	79	88
Singapore	2,787	75	15,626	540	------	------	3	2
South Africa, Republic of	19,769	451	132	12	7,237	128	132	32
Sweden	7,777	255	12,913	470	79	27	45	16
Taiwan	61,811	1,406	78,298	1,649	29	11	18	7
Turkey	53	2	---------	------	148	29	7	2
United Kingdom	1,423	69	2,964	175	1,216	306	983	239
Venezuela	8,084	341	20,654	790	261	75	355	85
Vietnam, South	6,994	260	8,500	296	226	37	23	5
Other countries	12,458	436	26,518	899	1,459	254	1,467	254
Total	1,146,131	35,010	1,339,491	39,610	29,060	4,886	33,397	5,114

[1] Less than ½ unit.

Table 10.—U.S. imports for consumption of potash materials

Material	Approximate equivalent as potash (K_2O) (percent)	1967				1968			
		Short tons	Approximate equivalent as potash (K_2O)		Value [1] (thousands)	Short tons	Approximate equivalent as potash (K_2O)		Value [1] (thousands)
			Short tons	Percent of total			Short tons	Percent of total	
Used chiefly as fertilizers:									
Muriate (chloride) [2]	60	2,748,637	1,649,182	[r] 96.6	$62,228	3,558,031	2,134,819	97.9	$68,748
Potassium nitrate, crude	40	[r] 19,423	[r] 7,769	[r] .5	[r] 697	16,001	6,400	.3	656
Potassium sodium nitrate mixtures, crude	14	44,825	6,276	.4	1,702	28,451	3,983	.2	1,009
Potassium sulfate, crude [2]	50	67,980	33,990	2.0	2,390	55,974	27,987	1.3	1,993
Other potash fertilizer materials	6	30,886	1,853	----------	218	12	----------	----------	(3)
Total	----------	[r] 2,911,751	[r] 1,699,070	99.5	[r] 67,235	3,658,469	2,173,189	99.7	72,406
Used chiefly in chemical industries:									
Bicarbonate	46	1,858	855	0.5	203	759	349	0.3	84
Bitartrate: Cream of tartar	25	1,229	307		591	1,296	324		647
Carbonate	61	4,562	2,783		652	440	269		68
Caustic	80	1,127	902		233	1,269	1,015		272
Chlorate and perchlorate	36	851	306		190	914	329		204
Cyanide	70	930	651		439	899	629		406
Ferricyanide	42	656	276		405	809	340		515
Ferrocyanide	44	1,921	845		714	2,197	967		944
Nitrate	50	1,260	630		146	1,145	573		138
Rochelle salts	22	289	64		118	293	64		118
All other	31	2,616	811		2,723	3,483	1,080		2,771
Total	----------	17,299	8,430	0.5	6,414	13,504	5,939	0.3	6,167
Grand total	----------	[r] 2,929,050	[r] 1,707,500	100.0	[r] 73,649	3,671,973	2,179,128	100.0	78,573

[r] Revised.

[1] Adjusted by the Bureau of Mines.

[2] Some information furnished by The American Potash Institute, Inc.

[3] Less than ½ unit.

Table 11.—U.S. imports for consumption of potash materials, by countries

(Short tons)

Year and country	Bitartrate cream of tartar	Caustic (hydroxide)	Chlorate and perchlorate	Cyanide	Muriate (chloride)[1]	Potassium nitrate, crude	Potassium sodium nitrate mixtures, crude	Potassium nitrate (saltpeter), refined	Potassium sulfate[1]	All others	Total	
											Quantity	Value[2] (thousands)
1967:												
Belgium-Luxembourg	--------	47	--------	--------	25,887	--------	--------	--------	4,149	1,855	31,938	$1,808
Canada	--------	--------	--------	11	2,298,531	--------	170	--------	223	560	2,299,495	53,192
Chile	--------	--------	--------	--------	4,417	r 19,268	37,372	--------	--------	--------	r 61,057	r 2,341
France	11	303	--------	110	129,404	25	5,559	--------	15,549	1,674	152,635	4,188
Germany:												
East	--------	--------	--------	--------	--------	--------	--------	--------	--------	73	73	37
West	50	475	15	483	176,514	130	1,724	787	29,668	4,765	214,611	7,095
Italy	691	--------	--------	--------	--------	--------	--------	403	18,391	30,630	50,115	1,410
Netherlands	--------	9	--------	--------	--------	--------	--------	--------	--------	2,369	2,378	716
Spain	366	--------	--------	--------	49,991	--------	--------	70	--------	89	50,516	1,454
Sweden	--------	289	615	--------	--------	--------	--------	--------	--------	--------	904	257
United Kingdom	--------	1	--------	103	3,001	--------	--------	--------	--------	182	3,287	213
Other countries	111	3	221	223	60,892	--------	--------	--------	--------	591	62,041	938
Total	1,229	1,127	851	930	2,748,637	r 19,423	44,825	1,260	67,980	42,788	r 2,929,050	r 73,649
1968:												
Belgium-Luxembourg	--------	141	--------	--------	18,372	--------	--------	--------	2,522	479	21,514	1,243
Canada	--------	--------	--------	6	3,209,142	105	83	--------	150	331	3,209,817	61,675
Chile	--------	--------	--------	--------	--------	15,630	19,915	--------	--------	--------	35,545	1,383
France	5	321	--------	83	80,410	--------	8,440	--------	23,092	844	113,195	3,166
Germany:												
East	--------	--------	--------	--------	--------	--------	--------	--------	--------	70	70	36
West	(3)	437	15	403	107,857	152	5	682	22,920	1,850	134,321	4,561
Italy	913	--------	--------	--------	--------	--------	--------	377	7,290	37	8,617	807
Netherlands	--------	18	--------	--------	--------	64	--------	--------	--------	2,688	2,770	1,082
Spain	344	--------	44	--------	73,566	--------	--------	73	--------	156	74,183	1,711
Sweden	--------	326	605	--------	--------	--------	--------	--------	--------	(3)	931	270
United Kingdom	--------	--------	1	93	(3)	--------	--------	13	--------	399	506	217
Other countries	34	26	249	314	68,684	50	8	--------	--------	1,139	70,504	2,422
Total	1,296	1,269	914	899	3,558,031	16,001	28,451	1,145	55,974	7,993	3,671,973	78,573

r Revised.

[1] Some information furnished by The American Potash Institute, Inc.

[2] Adjusted by Bureau of Mines.

[3] Less than ½ unit.

WORLD REVIEW

Australia.—Magellan Petroleum Australia Ltd. and three associates began drilling the first of two 5,000-foot exploratory wells in the Shark Bay area, 400 miles north of Perth, Western Australia. The exploration program is centered on 2 million acres of land extending around Shark Bay, which adjoins the Indian Ocean. The venture was undertaken as a result of a test well drilled in 1967 that showed evaporite deposits containing high percentages of bromine, an indicator of potash. Shark Bay is close to markets in Oceania and Japan.[2]

Plans by Texada Mines Pty. Ltd., to establish Australia's first potash plant at Lake McLeod were expected to be completed within a few months, but the enormous quantity of byproduct salt that would be produced in competition with other producers of salt in the area was still causing great concern to the Western Australia Government and the salt producers in the State. Texada planned to spend $13 million (Australian) at Lake McLeod for the potash plant and by 1971 produce 200,000 long tons of potash annually. The Texada plant reportedly could make Australia self-sufficient in potash.[3]

Canada.—Saskatchewan is fast becoming the world's largest producer of potassium raw material. Seven plants, representing an investment of $428 million and having a total capacity of 8.45 million short tons of potassium chloride (KCl), or 5.07 million tons of K_2O equivalent, were in operation by yearend 1968. By 1971, three more planned operations will increase total investment to $649 million and total capacity to 12.15 million short tons of KCl (7.29 million tons of K_2O equivalent).[4]

At Allen Potash Mines, 35 miles southeast of Saskatoon, the excavation joining the service and rock-hoisting shafts was completed in April. The new, 10-foot borer, continuous mining machine, used for the first time in a potash mine, performed satisfactorily.

The cargo vessel Nelson C. White, chartered by IMC, made her maiden trip from Vancouver, B.C., to Port Sutton, Fla., carrying 33,500 short tons of potash from IMC's mines in Saskatchewan. The ship returned with 35,000 short tons of phosphate rock from the company's Florida operations.[5]

Ethiopia.—Thick halite deposits in the deepest portion of the extensive Danakil area in northern Ethiopia contain at least two horizons of potash. So far, only the upper one has been explored underground for potash, and this work was done at

---

[2] Skillings Mining Review. Potash Exploration in Western Australia. V. 57, No. 39, September 1968, p. 12.

[3] Bureau of Mines. Mineral Trade Notes. V. 65, No. 12, December 1968, pp. 27–28.

[4] Koepke, W. E. Potash. Canadian Minerals Yearbook 1967, preprint June 1968, 9 pp.

[5] Phosphorus and Potassium. Nelson C. White Maiden Voyage. No. 35, May–June 1968, p. 47.

Table 12.—World production of marketable potash, by countries[1]

(Thousand short tons, K_2O equivalent)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada	858	1,491	1,990	[r] 2,383	2,891
United States	2,897	3,140	3,320	3,299	2,722
Europe:					
France	1,991	2,081	1,964	[r] 2,004	1,895
Germany:					
East	2,047	2,123	2,211	[r] 2,432	2,425
West	2,426	2,629	2,525	[r] 2,349	2,447
Italy	[r] 219	[e] [r] 256	[e] [r] 277	[e] [r] 270	[e] 293
Spain	380	475	[r] 535	[r] 629	[e] 653
U.S.S.R	2,425	[r] 2,610	[r] 2,895	[r] 3,161	[e] 3,472
Asia: Israel [2]	[r] 172	[r] 323	[r] 342	[r] 331	342
Total [3]	[r] 13,415	[r] 15,128	[r] 16,059	[r] 16,858	17,140

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Chile also produces potash-bearing materials as nitrate compounds; data on K_2O equivalent are not available, but the quantity is relatively small.

[2] Year ended March 31 of year following that stated.

[3] Totals are of listed figures only.

Musley where the deposit is shallow and being prepared for commercial operations. At Musley, the upper horizon of potash ore, from the top downward, contains a zone of sylvite ore ranging up to 36 feet in thickness, an intermediate zone of carnallite ore from 10 to 80 feet thick, and a basal zone of kainite, 13 to 43 feet thick.[6]

France.—The European Investment Bank in Luxembourg reportedly loaned $17 million to Mines de Potasse d'Alsace, the State-owned potash monopoly, for modernizing the potash mines in the Mulhouse area. France's annual output of 1.8 million metric tons of potash will eventually come from the three most economical mines and processing units.[7]

Germany, West.—The market situation for potash (K_2O) in West Germany was reported as follows (in short tons): Domestic production, 2,447,128; domestic deliveries, 1,309,544; exports, 1,214,746; and imports, 49,604. Potash was exported to approximately 50 countries, with the seven largest shipments, in short tons, going to Poland, 181,000; France, 132,277; United States and Puerto Rico, 83,996; Denmark, 83,445; Netherlands, 78,815; Belgium 73,193; and Cuba, 53,903.

Morocco.—Potash deposits near Khemisset were studied by a research team financed by the United Nations. Sixteen deep holes, drilled in 1967, had revealed reserves estimated at 40 million metric tons of sylvinite and 200 million tons of carnallite. The team's objectives were to search for new reserves of sylvinite, which is easier to develop than carnallite, and to develop better methods to utilize the known deposits.[8]

Pakistan.—West Pakistan Industrial Development Corp. started to deep-drill a brine deposit at Dhariala, about 120 miles southeast of Rawalpindi, for further information on the flow quantity, quality, and pressure. The deposit was believed to contain 25 million barrels of brine containing 6.5 percent potassium chloride.

The U.S. Geological Survey described some occurrences of potash in West Pakistan.[9]

TECHNOLOGY

Some promising results were obtained by the Bureau of Mines in its studies on beneficiating potash ores from New Mexico by heavy liquid techniques. Three different ores were tested, each one having a unique liquid separation problem. One ore was upgraded to 59 percent K_2O, with a 90 percent recovery, which compares favorably with commercial ores containing a minimum of 60 percent K_2O. The second ore was upgraded to 50 percent K_2O; it would however, have to undergo another purification step to remove carnallite in order to make the ore commercially attractive. The third ore was upgraded to 59 percent K_2O, with 80 percent recovery.[10]

Texas Gulf Sulphur Co. (TGS) finished drilling its 6-foot-diameter vertical auxiliary shaft to a depth of 2,710 feet at its Crane Creek potash operations near Moab, Utah, in January. The top 254 feet were drilled by conventional drilling and blasting methods and the balance by rotary drilling techniques. The shaft was said to be the largest privately owned, rotary-drilled shaft in the United States. The drill rig was 134 feet high, and the rotary drill, weighing 150 tons, was driven by a 1,500-horsepower motor. The 40-foot-long drill-bit assembly contained stabilizers, reamers, and a 6-foot-diameter bit. Two types of bits were used—sharp teeth to cut the sand and shale formations to a depth of 800 feet, and tungsten carbide inserts to cut the limestone formations below. The shaft, advanced 20 feet per day through limestone. Rock cuttings were removed by water (3,000 gallons per minute) and compressed air. Later, the shaft was lined with 34 sections of steel tubing, each 4 feet in inside diameter, 80 feet long, and ½ to 1½ inches thick, depending on the depth installed. Three-inch thick steel rings were welded at 4-foot intervals along the outside of the tubes, and the tubes were joined by welds. The space between the rock and lining was filled with cement.[11]

---

[6] Holwerda, J. G., and R. W. Hutchinson. Potash-Bearing Evaporites in the Danakil Area, Ethiopia. Econ. Geol., v. 63, No. 2, March–April 1968, pp. 124–150.

[7] European Chemical News (London). E. I. B. Loans To Aid French Potash Mines. V. 14, No. 359/60, Dec. 20–27, 1968, p. 52.

[8] Bureau of Mines. Mineral Trade Notes. V. 65, No. 8, August 1968, p. 24.

[9] Jones, C. L., and Asrarullah. Potential for Potash and Other Evaporite Mineral Resources in West Pakistan. U.S. Geol. Survey, open file, 1968, 17 pp.

[10] Tippin, R. B., and James S. Browning. Heavy Liquid Cyclone Concentration of Minerals (in Two Parts). 2. A Study of Liquid Cyclone Concentration of Various Mineral Systems. BuMines Rept. of Inv. 7134, June 1968, 53 pp.

Occidental Petroleum Corp. announced that its subsidiary, Garrett Research and Development, acquired leases near Searles Lake, California, and developed a promising new low-cost method for recovering potash and other products from the deposits. The firm also reported that the Searles Lake deposits were much larger than previously envisioned.[12]

A new crawler-mounted machine for continuous mining of potash became available. Sharp-toothed buckets, mounted on a rotating wheel at the end of a short boom, rip out the rock, which then falls into the buckets. The loaded buckets dump the rock on a small conveyor, which in turn feeds a long conveyor, for delivery to shuttle cars or other vehicles. The machine, 31 feet long, 8 feet 11 inches high (operational height), and 7 feet 7 inches wide, has a maximum capacity of 530 cubic yards per hour. It excavates an opening 10 feet high by 28 feet wide in one full sweep of the rotating cutting wheel.[13]

---

[11] Phosphorus and Potassium. Second Shaft for Texas Gulf Sulphur's Crane Creek Mine. No. 34, March–April 1968, pp. 43–44, 47.

[12] Engineering and Mining Journal. Potash Salts Knot Unraveled by Occidental. V. 169, No. 12, December 1968, p. 13.

[13] Mining World. New Continuous Potash Miner Has Rotating Bucket Wheel Cutter. V. 4, No. 2, February 1968, p. 37.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/176

Pumice

By Carl L. Bieniewski [1]

Pumice and pumiceous materials sold or used by domestic producers in 1968 totaled 3.5 million tons valued at $5.6 million, an increase of 2 percent in quantity and 9 percent in value over the 1967 output.

DOMESTIC PRODUCTION

Fifteen States and American Samoa had pumice production in 1968; Wyoming, which had production in 1967, had none in 1968 and Montana, which had no production in 1967, had some in 1968. Domestic output came from 164 mines operated by 136 companies, individuals, and State and Federal agencies; production in American Samoa came from one mine of the Samoan Government. Arizona with 29 active mines and 29 percent of the domestic output continued for the eighth year as the leading State in quantity produced. California had the most active mines, 44, and was second in production with 22 percent of domestic output.

Eighty-six percent of the domestic pumice output was volcanic cinder and the balance pumice and other pumiceous material. Volcanic cinder production came from 13 of the 15 States and American Samoa. All production from Colorado, Kansas, Montana, Oklahoma, Texas, and American Samoa was classed as volcanic cinder.

---

[1] Mining engineer, Bureau of Mines, Denver, Colo.

Table 1.—Pumice sold or used by producers in the United States[1]

(Thousand short tons and thousand dollars)

Year	Pumice and pumicite		Volcanic cinder		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1964	1,165	$4,094	1,611	$2,349	2,776	$6,443
1965	483	2,442	2,888	4,108	3,371	6,550
1966	549	2,629	2,669	4,136	3,218	6,765
1967	776	1,446	2,670	3,685	3,446	5,131
1968	481	1,360	3,049	4,210	3,530	5,570

[1] Values 1964–66 f.o.b. mine and/or grinding plant; values 1967–68 f.o.b. mine.

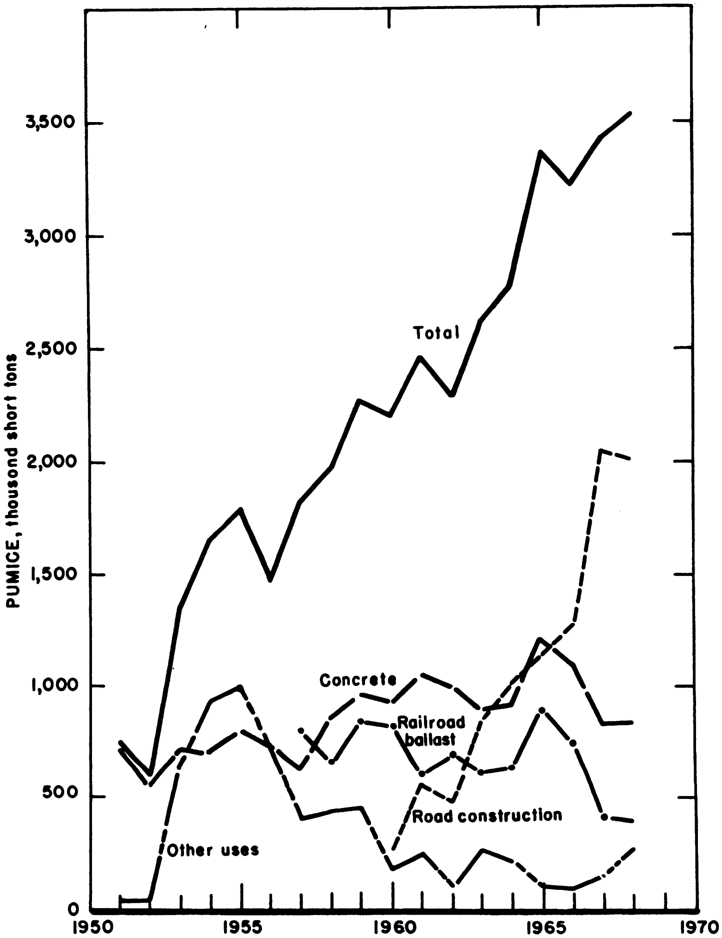

Figure 1.—Pumice sold or used by producers in the United States, by uses.

Table 2.—Pumice[1] sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1967		1968		State	1967		1968	
	Quantity	Value	Quantity	Value		Quantity	Value	Quantity	Value
Arizona	1,064	$904	1,033	$974	Nevada	105	$236	62	$144
California	866	1,357	776	1,312	New Mexico	220	689	248	527
Colorado	18	105	28	234	Oregon	834	1,195	725	977
Hawaii	290	562	408	724	Utah	W	W	8	19
Idaho	W	W	135	259	Other States [2]	49	132	8	62
Kansas	W	W	11	10					
Montana	-----	-----	93	327	Total [3]	3,446	5,131	3,530	5,570
					American Samoa	28	24	21	51

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes pumicite and volcanic cinder.

[2] Nebraska, Oklahoma, Texas, Washington, and Wyoming (1967), and States indicated by symbol W.

[3] Data may not add to totals shown because of independent rounding.

CONSUMPTION AND USES

Fifty-seven percent of the domestic pumice output was used for road construction, 24 percent as concrete admixtures and concrete aggregates, 11 percent for railroad ballast, and 8 percent as abrasive material and for miscellaneous uses. These percentages were virtually the same for these uses as in 1967.

PRICES

The average value of crude pumice sold or used decreased from $1.13 per ton in 1967 to $1.11 in 1968, whereas that for prepared pumice increased from $2.19 per ton to $2.36. The weighted average value of the two categories increased from $1.49 per ton in 1967 to $1.58. The average 1968 price for pumice used in cleaning and scouring compounds was $4.23 per ton, a $0.23 increase over that of 1967; concrete admixtures and concrete aggregates $2.04, a $0.07 decrease; railroad ballast $0.90, a $0.04 increase; and road construction $1.20, an $0.11 increase.

Nominal price quotations for domestic and imported pumice were carried regularly in trade publications. In the yearend issue (December 30, 1968) of Oil, Paint and Drug Reporter, the following prices were published per pound, bagged, in ton lots: Domestic, fine and coarse, $0.0430; domestic, medium, $0.0480; imported (Italian), silk-screened, fine, $0.07, and coarse, $0.04875; and per ton, bagged, imported (Italian), sundried, fine and coarse, $91. After its last issue in 1967, Metals Week discontinued publishing nonmetallic prices including those for pumice. Engineering and Mining Journal carried throughout the year the following prices for pumice stone per pound, in barrels, f.o.b. New York or Chicago: Powdered, $0.035 to $0.06, and lump, $0.06 to $0.08.

Table 3.—Pumice[1] sold or used by producers in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1967		1968	
	Quantity	Value	Quantity	Value
Abrasive: Cleaning and scouring compounds	14	$56	13	$55
Concrete admixture and concrete aggregates	833	1,761	839	1,711
Railroad ballast	412	355	397	356
Road construction [2]	2,049	2,236	2,007	2,417
Other uses [3]	138	724	275	1,032
Total [4]	3,446	5,131	3,530	5,570

[1] Includes pumicite and volcanic cinder.

[2] Includes ice control and maintenance.

[3] Includes abrasive uses (miscellaneous), acoustic plaster, asphalt, heat or cold insulating medium, landscaping, roofing, and miscellaneous uses.

[4] Data may not add to totals shown because of independent rounding.

FOREIGN TRADE

Pumice was exported to 16 countries, five more than in 1967, and the quantity increased 82 percent. Canada received 73 percent of the exported pumice and Japan was second with 18 percent.

Table 4.—U.S. exports of pumice

Year	Short tons	Value (thousands)
1965	282	$56
1966	298	66
1967	343	64
1968	624	54

Pumice imports were substantially greater than those of 1967 except for that classed as manufactured, n.s.p.f., which showed a decrease in value from $22,000 to $17,000. Most of the imports were classed as for use in the manufacture of concrete masonry products; the quantity imported under this class increased 26 percent. Pumice classed as crude or unmanufactured was 65 percent greater in quantity than that in 1967 and pumice classed as wholly or partly manufactured increased 53 percent. Italy and Greece were the principal sources of the imports.

Pumice stone to be used in the manufacture of concrete products, such as building blocks, bricks, tiles, and similar forms, continued to be imported duty free. The rates of duty for the other classes of pumice were reduced during 1968 as follows: Crude or crushed valued not over $15 per ton, from 0.038 cent per pound to 0.034 cent and that valued over $15 per ton, from 0.07 cent per pound to 0.06 cent; grains or ground, pulverized or refined, from 0.31 cent per pound to 0.28 cent; and millstones, abrasive wheels, and abrasive articles, n.s.p.f., from 12.5 percent ad valorem to 11 percent ad valorem.

Table 5.—U.S. imports for consumption of pumice, by classes and countries

Country	Crude or unmanufactured		Wholly or partly manufactured		Used in the manufacture of concrete masonry products		Manufactured, n.s.p.f.	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1967:								
Greece	------	------	------	------	125,554	$271	------	------
Honduras	52	$1	------	------	------	------	------	------
Italy	5,650	48	2,083	$76	111,736	231	NA	$9
Leeward and Windward Islands	------	------	------	------	900	2	------	------
Other countries [1]	------	------	------	------	------	------	NA	13
Total	5,702	49	2,083	76	238,190	504	NA	22
1968:								
Austria	------	------	2	5	------	------	------	------
Greece	------	------	------	------	184,080	367	------	------
Italy	9,436	69	3,189	116	114,969	248	NA	11
Other countries [2]	------	------	------	------	------	------	NA	6
Total	9,436	69	3,191	121	299,049	615	NA	17

NA Not available.

[1] Canada, Hong Kong, Japan, Netherlands, and West Germany.

[2] Canada, Hong Kong, United Kingdom, and West Germany.

WORLD PRODUCTION

Table 6.—World production of pumice and related volcanic materials by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
Argentina [2]	4,383	7,158	[r] 14,775	[p] 2,995	NA
Austria: Pozzolan	25,223	22,516	23,238	24,950	19,925
Cape Verde Islands: Pozzolan	11,296	4,562	3,097	NA	NA
Chile: Pozzolan	155,885	[r] 155,415	160,291	147,905	172,390
France:					
Pumice	1,010	780	888	690	[e] 700
Pozzolan and lapilli	645,547	782,136	740,370	797,387	[e] 794,000
Germany, West (marketable)	6,416,547	5,617,372	5,941,686	4,559,113	[e] 4,244,000
Greece:					
Pumice	252,500	302,140	218,255	250,883	311,951
Pozzolan	345,745	377,879	508,574	496,972	523,592
Guatemala: Volcanic ash (for cement)	45,243	35,170	30,864	48,816	46,297
Iceland	11,000	[e] 11,000	[e] 11,000	[e] 11,000	[e] 11,000
Italy:					
Pumice	679,206	[r] 591,497	[r] 639,632	546,023	NA
Pumicite	382,061	[r] 309,195	212,303	[e] 220,000	NA
Pozzolan	4,483,622	4,265,113	4,197,750	4,716,521	NA
Kenya	1,585	1,145	874	134	----------
Martinque:[3]					
Pumice	[e] 17,000	11,023	19,378	16,534	16,501
Tuff	[e] 491,000	308,644	173,722	281,527	173,612
New Zealand	22,980	120,807	20,204	18,081	[e] 19,000
Spain [4]	2,528	62,099	107,758	[e] 110,000	NA
United Arab Republic [e] [5]	14,000	15,100	----------	4,630	5,200
United States (sold or used by producers):					
Pumice and pumicite	1,165,379	484,087	548,433	776,388	481,345
Volcanic cinder	1,611,093	2,888,006	[6] 2,685,324	[6] 2,697,913	[6] 3,069,584
Total [7]	[r] 16,784,833	[r] 16,372,844	[r] 16,258,416	[r] 15,728,462	NA

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Pumice is also produced in Dominica, Guadeloupe, Japan, Mexico, and U.S.S.R. (sizable quantity), but data on production are not available. Japan's last available output figure was 110,000 tons in 1958.

[2] Unspecified volcanic materials produced mainly for use in construction products.

[3] Data converted from cubic meters on basis of reported specific gravity of 1.0 for pumice and 2.0 for tuff.

[4] Includes Canary Islands.

[5] Estimated on basis of 1 cubic meter =1,300 pounds.

[6] Includes American Samoa.

[7] Totals are of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/33

Rare-Earth Minerals and Metals

By John G. Parker [1]

The apparent domestic industrial consumption of rare-earth and yttrium compounds, expressed as rare-earth oxide (REO) equivalent, rose to over 6,800 tons, about 33 percent higher than in 1967. Helping greatly to raise the total was increased production and demand for rare-earth chlorides for petroleum cracking catalysts. Depressed sales of europium and yttrium oxides, due to less demand by color television phosphor producers, caused the total value of rare-earth sales to drop about about 20 percent.

Legislation and Government Programs.—At the end of 1968 the General Services Administration (GSA) held a total of 15,038 tons of equivalent REO in the forms of monazite, bastnaesite, chloride, and rare-earth sodium sulfate in the strategic and supplemental stockpiles. The 10,054 tons in the strategic stockpile consisted of 5,081 tons of monazite, including sweepings and contaminated material; 3,243 tons of bastnaesite; 653 tons of chloride; and 1,077 tons of rare-earth sodium sulfate. The 4,984 tons REO in the supplemental stockpile was all in the form of sodium sulfate. Of the rare-earth materials authorized for disposal in November 1967 by H.R. 5785, only rare-earth sodium sulfate was sold or committed for sale.

DOMESTIC PRODUCTION

Concentrate.—In 1968 production at the mining and milling facility of Molybdenum Corporation of America (Molycorp.) at Mountain Pass, Calif., declined to 11,400 tons of REO in bastnaesite concentrates compared with the 1967 total of 12,750 tons.[2]

Alluvial deposits at Folkston, Ga., owned by E. I. du Pont de Nemours & Co., Inc., again were worked by Humphreys Mining Co. for titanium and zirconium mineral concentrate with recovery of a substantial quantity of byproduct monazite. In March, Carpco Research and Engineering, Inc., finished reclaiming monazite and a small quantity of xenotime from beach sand processing residues owned by Titanium Alloy Manufacturing Division of National Lead Co. near Jacksonville, Fla. At the Climax, Colo., mine owned by Climax Molybdenum Co., low-grade monazite concentrate was extracted in tungsten mineral beneficiation and sold for further upgrading.

Compounds and Metals.—Production and sales of europium oxide from the solvent extraction facility at Mountain Pass decreased considerably as makers of color television phosphors still were drawing from inventories they had built up in the previous 2 years. The drop in europium oxide sales was offset by an increase in shipments of lanthanum chloride, made at the company's York, Pa., plant, which were needed for petroleum cracking catalysts, and in sales of other rare-earth materials. The solvent extraction plant at Louviers, Colo., produced yttrium oxide and other high-purity oxides such as those of gadolinium, lanthanum, and praseodymium. Also, Molycorp agreed to procure rare-earth oxides such as terbium, erbium, and holmium from a Japanese rare-earth producer to be added to its product line.[3]

Other major rare-earth chemical processors included American Potash & Chemical Corp., a division of Kerr-McGee Corp., West Chicago, Ill.; and W. R. Grace, Davison Chemical Division, Chattanooga, Tenn., and Pompton Plains, N.J. Smaller producers of rare-earth compounds were as follows: Atomergic Chemetals Co., Division of Gallard-Schlesinger Chemical Manufacturing Corp., Carle Place, N.Y.; Research Chemicals, Division of Nuclear Corporation of America, Phoenix, Ariz.; Michigan Chemical Corp., St. Louis, Mich.; and Transelco, Inc., Penn Yan, N.Y., which specialized in making low-cost cerium oxide for polishing compounds. Besides the Molycorp Louviers, Colo., plant, other major producers of yttrium oxide included American Potash, Michigan Chemical, and W. R. Grace, with smaller firms including Gallard-Schlesinger and Nuclear Corp. of America. Silicon compounds, containing rare-earth metals, were produced by Molycorp, Washington, Pa., and by Union Carbide Corp., Alloy, W. Va., for use as metal additives.

---

[1] Physical scientist, Division of Mineral Studies.

[2] Molybdenum Corporation of America. 1968 Annual Report. Mar. 14, 1969, 8 pp.

[3] Work cited in footnote 2.

Again only two companies, Ronson Metals Corp., Newark, N.J., and American Metallurgical Products Co., Inc., New Castle, Pa., produced misch metal. Most of the misch metal was destined for use in lighter flints. Total sales of misch metal by both producers were about 5 percent greater than those in 1967. Producers of higher purity rare-earth metals included American Potash; Gallard-Schlesinger; Lunex Co., Pleasant Valley, Iowa; Michigan Chemical; Nuclear Corp.; and Ronson. Nuclear Corp. and Lunex also produced high-purity yttrium metal.

CONSUMPTION AND USES

Consumption of bastnaesite concentrate by chemical processors increased about 3 percent but that of monazite concentrate was only about 36 percent of 1967 consumption.

Based largely on shipments from chemical processors to domestic consumers as well as on actual consumption data, the apparent domestic industrial consumption of rare-earth compounds increased over 40 percent to about 6,800 tons of REO equivalent but that of ytrrium oxide was less than half of what it was in 1967. Because of the decline in sales of europium and yttrium oxides for use in color television phosphors, the value of rare-earth compounds shipped decreased to about $12 million, of which europium and yttrium oxides formed nearly 30 percent. It was estimated that in 1968, quantities of REO used by consuming industries were as follows: 59 percent as rare-earth and lanthanum chlorides, into gasoline cracking catalysts; 18 percent usually as chloride, into metal production, mostly for making misch metal which itself is used primarily in lighter flints; 17 percent as the oxide and hydrate into the glass industry, mostly for use as polishing compounds, with increasing quantities used as glass additives; 5 percent as fluoride and oxide into the manufacture of arc carbons; and less than 2 percent into other applications, including a small quantity for phosphor and electronic uses.

Shipments of misch metal were 5 percent greater than in 1967, and those of higher purity rare-earth metals were 10 percent greater. Although the value of over 11,000 pounds of purportedly higher-purity metals, including yttrium, was nearly $350,000, over 90 percent by weight from one producer was of lower value than the rest, indicating that this was a lower purity product.

Although europium and yttrium oxides in color television phosphors have been well established, sales of the oxides were seriously affected by a more efficient use of the phosphors by television picture tube makers, by the drawdown of the large stocks of oxide held by the phosphor makers, and a lesser demand for color television tubes than had been expected. Partly offsetting the drop in sales of the television oxides was an increase in sales of lanthanum oxide for use in optical lenses and in fiber optics, of gadolinium oxide for use in phosphors and in microwave garnets; and of praseodymium oxide, mixed with zirconium dioxide, in a bright yellow ceramic tile stain. Likewise, slowing the downtrend in the value of sales was the rapidly growing use of rare-earth and lanthanum chlorides in a licensed petroleum cracking catalyst made by at least five companies.

Using rare-earth materials, advances were made in petroleum cracking catalysts. The author of a paper presented at a symposium held in Philadelphia March 31 to April 4, 1968 said that zeolite (a hydrous aluminosilicate mineral) and molecular sieve (synthetic zeolite) catalysts, with rare-earth elements replacing sodium in the crystal structure, afford higher gasoline yields, lower coke make, and improve activity.[4] In 4 years, from 1964 to 1968, the percentage of units using zeolites in cracking grew from practically zero to 87 percent.

Besides the well-known use of low-grade oxides for polishing eyeglasses, mirrors, television tubes, and camera and instrument lenses, certain rare-earth oxides are added to glass as decolorants (cerium oxide) and colorants (neodymium, praseodymium, and erbium oxides). An important use of lanthanum oxide is in camera lens compositions where it increases the refractive indices and decreases dispersion of the glass. Also, lanthanum oxide markedly improves the alkali resistance of glass used in food containers and glass-lined processing equipment. In refractories, the tetragonal structure of zirconium dioxide was stabilized by adding yttrium oxide, thereby preserving high density and minimizing thermal conductivity and expansion.

In lasers, room-temperature neodymium-doped calcium fluorophosphate crystal was said to be an efficient generator of pure infrared laser light. Besides the currently established use of europium-activated yttrium orthovanadate, europium-activated gadolinium oxide was said to provide a phosphor 20 to 70 percent brighter than any current rare-earth television phosphors.

Additions of rare-earth oxides and fluorides to cores of carbon-arc electrodes create materials which emit intense white light and are used in military searchlights and in color motion picture photography and projection.

Some applications in nucleonics have been attempted in the past with control rods in nuclear reactors containing oxides of europium, gadolinium, dysprosium, or samarium, the addition of which to a base material makes a substance highly impervious to thermal neutrons. Recently, the High Flux Isotope Reactor (HFIR) at Oak Ridge National Laboratory has started to use europium dispersed in aluminum in a control rod.

In addition to its long use as the base for lighter flints, misch metal, together with other lower grade alloys or rare-earth metals, was used in ductile iron foundries because it prevents carbide formation in the iron and promotes good nodularity. In a paper presented at the Philadelphia materials conference, a typical cost of misch metal added to ductile iron was said to be only about 60 cents per ton of iron produced.[5] Adding misch metal to stainless steel promoted forgeability and hot workability. In magnesium alloys, additions of rare-earth metals improved tensile strength and creep resistance at elevated temperatures. Recent examples of these alloys are ZE63A, composed of magnesium with 2 to 3 percent misch metal, 5.5 to 6 percent zinc, 0.4 percent minimum zirconium; and ZE63B, which adds 0.75 to 1.25 percent silver to the preceding formula. These alloys and QE22A, composed of 1.2 to 3 percent didymium (mainly neodymium and praseodymium), 2 to 3 percent silver, 0.7 percent zirconium, and the rest magnesium, are finding increased use in missile, rocket, satellite, and aircraft components.

STOCKS

The quantity of bastnaesite concentrate held at yearend by the principal domestic mining company and chemical processors was less than one-half that at the end of 1967. The supply of monazite, held mostly by two chemical processors, was almost 3 times that of yearend 1967. On the other hand, stocks of rare-earth sodium sulfate, held by one processor, were only about one-third as great as those at the end of 1967. Excluding the Louviers, Colo., plant of Molycorp, stocks of refined yttrium oxide were only about 4 percent greater than those in 1967 but stocks of europium oxide, held mostly by the principal producer, were over 25 percent more than in 1967. Misch metal stocks in the hands of the two main producers and some of the major users, were almost the same as in the previous year, but stocks of pure metals were only about 73 percent of those at the end of 1967.

---

[4] Koffler, R. L. Rare Earths in Petroleum Cracking Catalysts. Pres. at the Symposium on Rare Earth Applications, Materials Conference. American Institute of Chemical Engineers, New York, N.Y. Preprint 11 B, 25 pp.

[5] Hirschhorn I. S. Metallurgical Applications of the Rare Earth Metals. Pres. at the Symposium on Rare Earth Applications, Part II. Materials Conference. American Institute of Chemical Engineers, New York, N.Y. Preprint 11 A, 18 pp.

PRICES

Carload lot prices for monazite sand were quoted in Metals Week at $180 to $200 per long ton, nominal. On the London market, the average c.i.f. prices per long ton of Australian monazite with a minimum of 60 percent REO plus ThO_2 ranged from £80 to £90 ($192 to $216) at the beginning of the year to £70 to £75 ($168 to $180) at the end, dropping to as low a range as £65 to £75 ($156 to $180) in September and October. Near midyear, prices on Malaysian xenotime concentrate with a minimum of 25 percent yttrium oxide, were quoted by Industrial Minerals (London) at $3 to $5 per pound yttrium oxide, c.i.f. Michigan Chemical Corp. quoted prices on processed yttrium concentrates of 60 and 90 percent grade at $13.50 per pound yttrium oxide content to $34.90 per pound yttrium oxide, depending upon lot size. According to Metals Week, domestic bastnaesite concentrates remained at, per pound f.o.b. Nipton, Calif.: 55 to 60 percent rare-earth oxides, 30 cents, and 68 to 72 percent rare-earth oxides, 35 cents. Rare-earth oxide from the same source was quoted at 45 cents per pound for 88 to 92 percent pure material. Other quoted prices for optical grade ceric oxide in lot sizes of 50 pounds or more, delivered in bags, were $1.85 to $1.90 per pound, and for cerium hydrate in lots of 100 pounds or more, depending upon purity, $1.40 to $1.74 per pound.[6]

In general prices of higher purity oxides remained as in 1967, but downward changes were noted on a price list for oxides of 99.9 percent purity in 2- to 99-pound lot sizes issued by Michigan Chemical Corp. and were as follows: Samarium oxide, $42.50 per pound instead of $45; europium oxide, $575 per pound (not quoted previously); gadolinium oxide, $90 per pound instead of $120; dysprosium oxide, $85 per pound instead of $90; ytterbium oxide, $135 per pound instead of $145; lutetium oxide, $3,000 per pound (not quoted previously); and yttrium oxide, $42 per pound instead of $53.

Quoted prices for cerium-free misch metal and didymium metal of 97 percent purity, from Ronson Metal Corp., remained at $5 per pound and $15 per pound, respectively.

Yttrium misch metal ingots of 60 percent and 90 percent yttrium content, available from Michigan Chemical Corp. in 2- to 25-pound lot sizes, were quoted at $95 per pound and $115 per pound, respectively. Cerium alloy, 52 to 58 percent grade, was quoted in Metal Bulletin (London) at 26 to 32 shillings ($3.12 to $3.84) per pound, net, delivered, until October when an alloy of 50 to 54 percent grade was quoted at 25 shillings ($3) nominal.

Prices of high-purity metal ingots from Michigan Chemical Corp. remained the same as in 1967, some of the metals being shown below:

Metal ingot, 99 + percent pure, 2- to 25-pound lots	*Dollars per pound (1968)*
Cerium and lanthanum	70
Europium	3,600
Gadolinium	240
Neodymium	115
Samarium	160
Yttrium	150

Cerium metal of 99 percent, quoted in Metal Bulletin at £21 ($50.40) per pound, net, delivered in the United Kingdom was lowered to £7 ($16.80) per pound, nominal, in October. However, lanthanum metal of 98 to 99 percent purity, remained at 17 shillings, 6 pence ($2.10) per gram throughout the year.

FOREIGN TRADE

Ferrocerium and other pyrophoric alloys, totaling 89,858 pounds worth $302,882, were exported to the United Kingdom, Canada, Japan, and 25 other countries. The average unit value of these exports was $1.22 per pound more than in 1967.

Monazite sand concentrate imports totaling 4,367 short tons, over twice that received in 1967, valued at $562,725 came from Australia (64 percent of weight) and Malaysia (35 percent) and Nigeria and West Germany, with the latter probably not the country of origin. The average unit value of these imports was only slightly less than that in 1967. One company reported receiving a small quantity of brannerite from Canada.

---

[6] Oil, Paint and Drug Reporter. Current Prices of Chemicals and Related Materials. V. 193, Nos. 1–26, Jan. 1–June 24, 1968; V. 194, Nos. 1–27, July 1–Dec. 30, 1968.

Cerium oxide from France, Finland, the United Kingdom, West Germany, and Switzerland totaled 10,550 pounds worth $16,855. The small quantities from Switzerland and West Germany had high unit values, indicating that they were special high-purity oxides. Cerium compounds, n.s.p.f., from Canada, France, and West Germany, totaled 11,123 pounds valued at $10,419.

Imports of rare-earth metals are shown in table 1.

The high unit values of the metals from the United Kingdom, U.S.S.R., and Japan indicated that they were of high purity. Over 99 percent by weight of the material, however, came from West Germany, and was of such low unit value that it was suspected to be of low-value alloys. Imports of low-value alloys, including misch metal, from Austria totaled 992 pounds worth $1,247. Other alloys of rare-earth metals, totaling 25 pounds valued at $375, were imported from West Germany. Ferrocerium and other pyrophoric alloys, from Japan, West Germany, Netherlands, Austria, United Kingdom, and France, totaled 23,003 pounds worth $77,186. The unit value of these materials was $1.48 per pound less than in 1967.

Table 1.—U.S. imports for consumption of rare-earth metals (including scandium and yttrium)

Country	1964		1965		1966		1967		1968	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
Canada	------	------	------	------	3,436	$21,361	------	------	------	------
France	------	------	------	------	17	269	------	------	------	------
Germany, West	859	$9,206	15,177	$31,153	24,357	42,856	11,023	$13,396	3,355	$18,516
Ireland	------	------	------	------	1	385	------	------	------	------
Japan	------	------	------	------	------	------	------	------	5	1,070
U.S.S.R	------	------	4	1,515	------	------	34	11,012	7	5,952
United Kingdom	1	1,149	1	3,771	50	10,137	9	5,744	7	5,181
Total	860	10,355	15,182	36,439	27,861	75,008	11,066	30,152	3,374	25,669

Table 2.—World production of monazite concentrates, by countries[1] [2]

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
Australia	2,219	2,582	2,222	3,254	3,591
Brazil	733	658	822	1,189	1,864
Ceylon	25	40	40	22	46
Congo, Republic of the (Kinshasa)	--------	22	NA	NA	--------
India [e]	2,307	2,800	2,900	2,900	2,900
Indonesia	154	28	NA	NA	NA
Korea, South [3]	--------	28	13	14	--------
Malagasy Republic	1,063	1,196	937	28	(4)
Malaysia (exports)	340	777	970	1,060	2,357
Nigeria [5]	11	9	8	126	7
Total [6]	6,852	8,140	7,912	8,593	10,765

[e] Estimate. [p] Preliminary. NA Not available.

[1] United States production data withheld to avoid disclosing individual company confidential data.

[2] Compiled mostly from data available May 1969.

[3] Reported as concentrates containing 45–55 percent of R_2O_3; also reported as 30 percent Ce, which may be high.

[4] Less than ½ unit.

[5] Year ended March 31 of year following that stated.

[6] Totals are of listed figures only.

WORLD REVIEW

Australia.—Based on monazite concentrate production data during the first 6 months, it appeared that the year's production of concentrate would be about 2,400 short tons containing 95 percent monazite.[7] In the first half of the year, 84 percent of the monazite was produced in Western Australia and the rest in Queensland.

Field Metals and Chemical Industries Pty. Ltd., formed from the merger of Field Group Research Pty. Ltd., Sydney, New South Wales, and Australian Ceramic Industries Pty. Ltd., Adelaide, South Australia, purchased the Port Pirie uranium treatment plant from the South Australian Government. The plant, which was closed down in 1962, will shortly be processing monazite and recovering rare-earth products, including the higher purity oxides now in demand.[8] After studying the prospects for recovering rare-earth concentrates from tailings from its Queensland mine which had closed in 1963, Mary Kathleen Uranium Ltd., owned mostly by Conzinc Riotinto of Australia, decided that the short-term market for these materials is limited and deferred its plans for 2 years.[9]

Canada.—Preliminary Dominion Bureau of Statistics data showed that 1968 production of yttrium oxide in concentrate from uranium milling dropped to 111,326 pounds valued at $865,000 compared with revised 1967 figures of 172,551 pounds valued at $1,475,000. The three producers, Denison Mines Ltd., Rio Tinto Nuclear Products Ltd., and Stanrock Uranium Mines Ltd., sold these concentrates respectively to Molybdenum Corporation of America (Molycorp) and Michigan Chemical Corp., to Thorium Ltd. and Molycorp, and to Michigan Chemical.

Congo (Kinshasa).—It is reported that the Karonge bastnaesite mine in Rwanda again offered concentrates to rare-earth processors.[10]

Finland.—It was said that Otanmaki Oy. was exploring a rare-earth-bearing carbonatite in northern Lapland.[11] Outokumpu Oy. daily milled 300 tons of ore from its Korsnas deposit which contains over 1 percent rare-earth oxides and 98 grams per ton of europium oxide.[12] This would amount to 3 tons of rare-earth oxides and 65 pounds of europium in the milled ore but flotation of the ore results in a rare-earth concentrate product containing 3.58 percent REO and 292 grams europium oxide per ton.

India.—The Alwaye plant, Kerala State, owned by Indian Rare Earths Ltd. (IRE), Bombay, was said to be able to treat 4,000 tons of monazite annually and also recover 4,600 tons of rare-earth chloride.[13] Supplies of monazite came from the Manavalakurichi separation plant in Madras State. In the year ending March 31, 1968, according to the firm's annual report released to the public on December 18, 1968, the mineral division produced 2,987 short tons of monazite concentrate and the rare-earth division produced 4,464 short tons of rare-earth chloride. By early 1970, IRE expected to have another beach sand processing plant in operation at Chavara, near Quilon, in Kerala State.

Kenya.—Pechiney St. Gobain signed an agreement with the Kenya Government to prospect and mine for rare-earth minerals in the Mrima Hills, 40 miles southwest of Mombasa.[14] Reserves of rare-earth elements in the area were estimated at 7 million tons of plus 5 percent REO and 35 million tons of 1.1 percent grade.

Malaysia.—Concentrates of xenotime, an yttrium phosphate mineral obtained in processing alluvial tin deposits, have sold recently at $3 to $5 per pound of yttrium oxide content.[15] A leading exporter of yttrium materials, Sharikat Harper Gilfillan Berhad, Kuala Lumpur, studied the possibility of chemically upgrading materials to

---

[7] The Australian Minerals Industry. Part 2—Quarterly Statistics. V. 21, No. 2, December 1968, p. 12.

[8] Industrial Minerals (London). REO Plant Planned at Port Pirie. No. 11, August 1968, p. 16.

[9] Industrial Minerals (London). No. 14, November 1968, pp. 18–19.

[10] Industrial Minerals (London). Congo. No. 14, November 1968, p. 20.

[11] Aho, A. E. Notes on Some Mines and Mineral Exploration in Finland. Canadian Min. J., v. 90, No. 1, January 1969, pp. 18–20.

[12] World Mining. Outokumpu Base Metal Concentrators. V. 4, No. 12, November 1968, pp. 26–29.

[13] Industrial Minerals (London). India—Range of Rare Earth Products Extended. No. 16, January 1969, p. 35.

[14] World Mining. Pechiney—St. Gobain Looks at Columbium-Rare Earth Deposit. V. 4, No. 12, November 1968, p. 17.

[15] Metal Bulletin (London). Yttrium Plant for Malaysia. No. 5337, Oct. 4, 1968, p. 25.

60 percent yttrium oxide, with technical support for the project provided by British Rare Earths Ltd. (BREL).

Somali Republic.—Acting on the request of the Somali Government, the United Nations explored a uranium, thorium, rare-earth deposit at Alio Ghelle, about 150 miles northwest of Mogadiscio.[16]

United Kingdom.—Thorium Ltd., which had won the 1967 Queen's Award for technological innovation, again was honored, this time with the 1968 Queen's Award for export achievement.[17] A new solvent extraction unit was added to the firm's new Widnes, Lancashire, facility.

TECHNOLOGY

Monazite, now secondary to bastnaesite as a source of rare-earth elements, was still of interest as a byproduct recovered from beach and stream placers which were utilized mostly for their zircon and titanium mineral content. As noted in the technology section of the Zirconium and Hafnium chapter, waste products from processed Florida phosphate rock may be potentially valuable for recovery of heavy mineral concentrates.[18] The Bureau of Mines, acting with industry, studied means for the possible recovery of marketable heavy mineral concentrates from phosphate operations and, in addition, tested the potential of certain sand and gravel operations for heavy mineral separation.

Other Bureau of Mines metallurgical research was conducted on enrichment and separation of rare-earth elements, producing high-purity rare-earth metals and alloys by direct electrolysis and developing methods for electrowinning cerium and lanthanum continuously, redistributing components in an alloy by a technique called field freezing, and cooperating with industry in testing the effect of rare-earth metals added to steel as a deoxidizer and desulfurizer.[19]

In a review article, the fluoride, chloride, and direct reduction processes for making rare-earth metals were discussed.[20] The author concluded at this time that industrial-scale producers would find it economically infeasible to try to achieve an ultimate purity product for every research requirement.

The Seventh Rare Earth Research Conference was held at Coronado, Calif., on October 28–30. The technical sessions dealt with subjects such as geochemistry; separation; inorganic, structural, and crystal chemistry; metal preparation; luminescence and fluorescence properties; solid state physics; magnetic behavior of metals; and industrial processes and applications.

Most of the research on high-purity rare-earth oxides concerned their luminescence properties. Phosphor systems used in color television and lighting, in which europium was the activator, were a prime subject for investigation. In one paper, the advantages of rare-earth-activated phosphors for such applications was discussed and specific examples presented.[21] The author explained why yttrium orthovanadate activated by europium oxide has potential in low- and high-pressure mercury discharge lamps and how, in television phosphors, trivalent samarium or europium can provide the basis for a red primary, trivalent thulium for blue, and trivalent terbium, holmium, or erbium for green. Depending upon the host material, divalent europium promoted blue and green fluorescence in some aluminate phosphors and a bright yellow body color in silicate phosphors.[22] Also discussed were the spectral properties of europium-, gadolinium-, terbium-, and other rare-earth-activated phosphors, europium-activated oxygen-sulfur compounds, and samarium-, europium-, or dysporsium-activated vanadates.[23]

---

[16] Industrial Minerals (London). Somali Republic. No. 14, November 1968, p. 20.

[17] Chemical Age (London). Thorium Gets Queen's Award Again and Commission New Rare Earth Plant. V. 98, No. 2570, Oct. 19, 1968, p. 11.

[18] Stow, Stephen H. The Heavy Minerals of the Bone Valley Formation and Their Potential Value. (Scientific Communications). Econ. Geol., v. 63, No. 8, December 1968, pp. 973–975.

[19] Bauer, D. J., and R. E. Lindstrom. Recovery of Cerium and Lanthanum by Ozonation of Lanthanide Solutions. BuMines Rept. of Inv. 7123, 1968, 9 pp.

Bauer, D. J., R. E. Lindstrom, and K. B. Higbie. Extraction Behavior of Cerium-Group Lanthanides in a Primary Amine-Chelating Agent System. BuMines Rept. of Inv. 7100, 1968, 12 pp.

Leary, R. J., R. T. Coulehan, H. A. Tucker, and W. G. Wilson. Effects of Adding Rare-Earth Silicides, Aluminum, and Cryolite to Molten Steel. BuMines Rept. of Inv. 7091, 1968, 42 pp.

Morrice, E., E. S. Shedd, and T. A. Henrie. Direct Electrolysis of Rare-Earth Oxide to Metals and Alloys in Fluoride Melts. BuMines Rept. of Inv. 7146, 1968, 12 pp.

Murphy, J. E., E. Morrice, and T. A. Henrie. Field Freezing of a Cerium-Iron Alloy. BuMines Rept. of Inv. 7186, 1968, 14 pp.

Tucker, H. A., R. T. Coulehan, and W. G. Wilson. Rare-Earth Silicide Additions to an Alloy Steel To Increase Toughness and Ductility. BuMines Rept. of Inv. 7153, 1968, 30 pp.

Winget, J. O., and R. E. Lindstrom. Amino Acids as Retaining Agents for Separation of Rare-Earth Elements on Ion-Exchange Resin. BuMines Rept. of Inv. 7175, 1968, 8 pp.

[20] Moriarty, John L., Jr. The Industrial Preparation of the Rare Earth Metals by Metallothermic Reduction. J. Metals, v. 20, No. 11, November 1968, pp. 41–45.

[21] Palilla, F. C. The Trivalent Rare Earths in Inorganic Phosphor Systems. Electrochem. Technol., v. 6, Nos. 1–2, January–February 1968, pp. 39–49.

In metallurgy, a promising field for rare-earth metals is in magnet material where samarium alloyed with cobalt has the highest intrinsic coercive forces, or resistance to demagnetization, of any known comparable material. Samarium-cobalt magnets are more powerful than the widely used aluminum-nickel-cobalt (Alnico) systems and the expensive platium-cobalt magnets.

---

[22] Blasse, G., and A. Bril. Fluorescence of Eu 2+-Activated Alkaline-Earth Aluminates. Philips Res. Rept. (Eindhoven, Netherlands), v. 23, No. 2, April 1968, pp. 201–206.

Blasse, G., W. L. Wanmaker, J. W. ter Vrugt, and A. Bril. Fluorescence of Eu 2+-Activated Silicates. Philips Res. Rept. (Eindhoven, Netherlands), v. 23, No. 2, April 1968, pp, 189–200.

[23] Haynes, James W., and Jesse J. Brown, Jr. Preparation and Luminescence of Selected Eu 3+-Activated Rare Earth Oxygen-Sulfur Compounds. J. Electrochem. Soc., v. 115, No. 10, October 1968, pp. 1060–1066.

Ropp, R. C. Phosphors Based on Rare Earth Phosphates. I. Spectral Properties of Some Rare Earth Phosphates. J. Electrochem. Soc., v. 115, No. 8, August 1968, pp. 841–845.

Ropp, R. C. Spectra of Some Rare Earth Vanadates. J. Electrochem. Soc., v. 115, No. 9, September 1968, pp. 940–945.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/28

Salt

By Benjamin Petkof[1]

The domestic output of salt continued to increase to meet industrial requirements. Total production in 1968 increased 6 percent in quantity and 8 percent in value. Almost two-thirds of the available domestic supply was consumed in the manufacture of chlorine, soda ash, and other chemicals. Slight increases for imports and exports were noted over those of 1966.

DOMESTIC PRODUCTION

Seventeen States recorded salt production during 1968, with Louisiana, Texas, Ohio, New York, and Michigan supplying 85 percent of the total output.

Salt was produced by 56 producers with 100 plants in the United States and Puerto Rico. Eleven companies, with production in excess of 1 million tons each and operating 42 plants, supplied 86 percent of total production; 16 companies, whose production was less than 1 million but greater than 100,000 tons per year operated 26 plants and supplied 12 percent of total production; and 29 companies whose individual production was under 100,000 tons per year operated 32 plants to supply the remaining material.

Twelve plants, with an annual production of over 1 million tons each supplied 56 percent of total domestic production; and 14 plants producing 500,000 tons to 1 million tons each, annually, supplied 23 percent. The remainder was supplied by 73 plants.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Salient salt statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Sold or used by producers	31,623	34,687	36,463	38,946	41,274
Value	$200,706	$215,699	$229,985	$251,210	$272,275
Exports	594	688	662	678	728
Value	$3,878	$4,285	$4,472	$4,583	$4,650
Imports for consumption	2,261	2,410	2,479	2,843	3,456
Value	$5,677	$6,505	$6,464	$8,541	$11,487
Consumption, apparent	33,290	36,409	38,280	41,111	44,002
World: Production	108,720	119,730	122,274	131,564	124,442

Table 2.—Salt sold or used by producers in the United States, by methods of recovery

(Thousand short tons and thousand dollars)

	1967		1968	
	Quantity	Value	Quantity	Value
Evaporated:				
Bulk:				
Open pans or grainers	356	$10,608	322	$8,518
Vacuum pans	2,860	65,515	2,943	69,253
Solar	1,729	11,356	1,900	12,805
Pressed blocks	344	8,367	357	9,246
Total	5,289	95,846	5,522	99,822
Rock:				
Bulk	11,598	70,100	12,376	77,546
Pressed blocks	63	1,853	85	2,321
Total	11,661	71,953	12,461	79,867
Salt in brine (sold or used as such)	21,996	83,411	23,291	92,586
Grand total	38,946	251,210	41,274	272,275

Table 3.—Salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1967		1968	
	Quantity	Value	Quantity	Value
California	1,732	W	1,901	W
Kansas [1]	1,069	$14,686	1,128	$15,520
Louisiana	9,585	48,483	10,908	53,854
Michigan	4,789	42,389	4,898	44,481
New Mexico	82	1,036	W	W
New York	5,320	41,568	5,218	42,488
Ohio	5,407	39,549	5,713	43,172
Oklahoma	10	76	7	44
Texas	8,344	36,435	8,534	42,663
Utah	403	3,525	405	3,756
West Virginia	1,127	5,137	1,308	4,971
Other States [2]	1,078	18,326	1,259	21,326
Total	38,946	251,210	41,274	272,275
Puerto Rico	12	195	32	395

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Quantity and value of brine included with "Other States."

[2] Includes Alabama, Colorado, Hawaii, Kansas (brine only), Nevada, North Dakota, Virginia, and States indicated by symbol W.

Table 4.—Evaporated salt sold or used by producers in the United States

(Thousand short tons and thousand dollars)

State	1967		1968	
	Quantity	Value	Quantity	Value
Kansas	521	$12,085	556	$12,875
Louisiana	301	7,619	293	7,183
Michigan	1,042	24,439	1,068	25,497
New York	729	16,512	W	17,183
Ohio	688	14,908	763	W
Oklahoma	7	67	5	37
Other States [1]	2,001	20,216	2,837	37,047
Total	5,289	95,846	5,522	99,822
Puerto Rico	12	195	32	395

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes California, Hawaii, Nevada, New Mexico (1967), North Dakota, Texas, Utah, and States indicated by symbol W.

Table 5.—Rock salt sold by producers in the United States

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1964	8,554	$52,290
1965	9,810	57,710
1966	10,080	61,118
1967	11,661	71,953
1968	12,461	79,867

Table 6.—Pressed-salt blocks sold by original producers of salt in the United States

(Thousand short tons and thousand dollars)

Year	From evaporated salt		From rock salt		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1964	387	$8,659	65	$1,725	452	$10,384
1965	375	8,701	68	1,767	443	10,468
1966	328	8,529	60	1,682	388	10,211
1967	344	8,367	63	1,853	407	10,220
1968	357	9,246	85	2,321	442	11,567

CONSUMPTION AND USES

The chemical manufacturing industry continued to consume more than two-thirds of the domestic salt output. Forty-two percent of the domestically produced material was used to manufacture chlorine and its byproduct caustic soda; 17 percent was used for the manufacture of synthetic soda ash; and 6 percent for other chemicals. Ice and snow removal and roadbed stabilization required 14 percent of total output. Salt assumed to be used as table salt represented 3 percent of the total. The use of salt for the regeneration of water softening systems increased 19 percent over the quantity consumed in 1968. Fifty-six percent of the total consumption was sold or used in the form of brine.

Table 7.—Salt sold or used by producers in the United States, by classes and consumers or uses

(Thousand short tons)

Consumer or use	1967				1968			
	Evaporated	Rock	Brine	Total	Evaporated	Rock	Brine	Total
Chlorine	451	1,561	14,223	16,235	328	1,593	14,810	16,731
Soda ash	W	W	6,823	6,825	W	W	6,972	6,974
Soap (including detergents)	23	8	------	31	29	7	------	36
All other chemicals	314	1,459	38	1,811	W	1,775	W	2,391
Textile and dyeing	W	94	W	189	W	98	W	244
Meatpackers, tanners, and casing manufacturers	297	431	------	728	W	389	W	694
Fishing	14	5	------	19	15	5	------	20
Dairy	46	4	------	50	47	5	------	52
Canning	183	W	W	233	189	W	W	246
Baking	W	W	------	113	W	W	------	117
Flour processors (including cereal)	59	9	------	68	62	9	------	71
Other food processing	152	W	W	188	158	W	W	201
Ice manufacturers and cold storage companies	W	13	W	20	W	7	W	15
Feed dealers	718	398	------	1,116	764	466	------	1,230
Feed mixers	323	W	W	464	297	W	W	491
Metals	W	121	W	249	69	199	------	268
Ceramics (including glass)	5	10	------	15	5	11	------	16
Rubber	W	W	13	112	W	W	54	125
Oil	63	49	126	238	54	51	87	192
Paper and pulp	16	124	13	153	W	144	W	321
Water softener manufacturers and service companies	335	W	W	688	419	W	W	813
Grocery stores	678	338	------	1,016	669	397	------	1,066
Railroads	6	27	------	33	7	25	------	32
Bus and transit companies	W	W	------	69	2	13	------	15
States, counties, and other political subdivisions (except Federal)	W	5,157	W	5,297	230	5,518	3	5,751
U.S. Government	W	31	W	66	31	36	W	68
Miscellaneous	1,081	1,183	661	2,925	1,094	1,062	938	3,094
Undistributed [1]	525	639	99	------	1,053	651	427	------
Total	5,289	11,661	21,996	38,946	5,522	12,461	23,291	41,274

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes some exports and consumption in overseas areas administered by the United States, and items indicated by symbol W.

Table 8.—Distribution (shipments) of evaporated rock salt in the United States, by destination

(Thousand short tons)

Destination	1967		1968	
	Evaporated	Rock	Evaporated	Rock
Alabama	40	427	44	350
Alaska	W	W	8	W
Arizona	W	W	W	5
Arkansas	16	83	18	96
California	759	W	852	W
Colorado	96	85	107	41
Connecticut	19	W	22	W
Delaware	8	W	8	W
District of Columbia	3	W	4	W
Florida	81	107	81	99
Georgia	56	W	57	222
Hawaii	W	------	W	------
Idaho	43	W	44	W
Illinois	281	461	295	635
Indiana	144	380	143	376
Iowa	174	243	176	225
Kansas	86	204	90	201
Kentucky	45	343	43	465
Louisiana	84	391	85	485
Maine	18	W	13	W
Maryland	46	116	76	41
Massachusetts	57	613	60	399
Michigan	180	W	168	W
Minnesota	155	341	146	269
Mississippi	17	72	25	72
Missouri	81	353	81	398
Montana	37	1	46	1
Nebraska	90	92	92	171
Nevada	22	W	27	W
New Hampshire	9	W	10	W
New Jersey	157	465	167	492
New Mexico	14	71	10	82
New York	354	W	332	1,742
North Carolina	105	161	112	190
North Dakota	42	4	47	4
Ohio	303	961	300	1,124
Oklahoma	34	56	41	60
Oregon	33	W	29	W
Pennsylvania	203	823	208	986
Rhode Island	12	W	12	71
South Carolina	32	20	38	23
South Dakota	36	21	42	19
Tennessee	129	290	122	366
Texas	113	422	111	518
Utah	154	W	121	W
Vermont	7	W	6	W
Virginia	88	124	95	110
Washington	W	W	W	W
West Virginia	21	108	23	119
Wisconsin	154	425	154	327
Wyoming	20	W	22	W
Other [1]	736	3,448	814	1,677
Total	5,289	11,661	5,522	12,461

W Withheld to avoid disclosing individual company confidential data; included with "Other."

[1] Includes shipments to overseas areas administered by the United States, Puerto Rico, exports, some shipments to unspecified destinations, and States indicated by symbol W.

PRICES

During most of the year The Oil, Paint and Drug Reporter quoted the price of salt per 100 pounds as follows: Common evaporated salt in 100-pound bags in car or truck lots at the works, $1.14; chemical grade on the same basis, $1.25; rock salt, medium or coarse on the same basis, $0.77; rock salt, extra coarse on the same basis, $0.82.

Based on reported production data, the average, per ton values of rock and evaporated salt were $18.08 and $6.27, respectively.

FOREIGN TRADE

Exports and imports of salt remained low compared with domestic production. Exports, the bulk of which went to Canada and Japan, increased about 7 percent in quantity over that of 1967. Imports increased about 22 percent. Major import sources were Canada, Mexico, the Bahamas, and Tunisia. These countries supplied 92 percent of total imports.

Table 9.—Salt shipped to the Commonwealth of Puerto Rico and overseas areas administered by the United States

(Thousand short tons and thousand dollars)

Area	1967 Quantity	1967 Value	1968 Quantity	1968 Value
American Samoa	(1)	$16	(1)	$9
Guam	(1)	19	(1)	13
Puerto Rico	11	840	18	1,730
Virgin Islands	(1)	17	(1)	20

[1] Less than ½ unit.

Table 10.—U.S. exports of salt by countries

(Thousand short tons and thousand dollars)

Destination	1967 Quantity	1967 Value	1968 Quantity	1968 Value
Australia	1	$56	1	$48
Canada	205	1,738	262	1,942
Costa Rica	(1)	19	4	54
Japan	460	2,098	441	1,954
Mexico	2	52	2	41
Saudi Arabia	1	60	1	112
South Africa, Republic of	1	18	2	15
Other	8	542	15	484
Total	678	4,583	728	4,650

[1] Less than ½ unit.

Table 11.—U.S. imports for consumption of salt, by countries[1]

(Thousand short tons and thousand dollars)

Country	1967 Quantity	1967 Value	1968 Quantity	1968 Value
Bahamas	270	$1,005	665	$2,490
Canada	1,436	4,860	1,455	5,515
Chile	78	218	169	553
Mexico	830	1,724	834	1,660
Spain	------	------	56	325
Tunisia	169	542	215	655
United Arab Republic	48	159	------	------
United Kingdom	(2)	1	21	153
Venezuela	12	32	23	62
Other	------	------	18	74
Total	2,843	8,541	3,456	11,487

[1] Includes salt brine from Canada through the Detroit customs district for 1967, 443,457 short tons valued at $128,839; 1968, 300,596 short tons valued at $89,187.

[2] Less than ½ unit.

Table 12.—U.S. imports for consumption of salt, by classes

(Thousand short tons and thousand dollars)

Year	In bags, sacks, barrels or other packages (dutiable) Quantity	In bags, sacks, barrels or other packages (dutiable) Value	Bulk (dutiable)[1] Quantity	Bulk (dutiable)[1] Value
1966	10	$208	2,469	$6,256
1967	14	282	2,829	8,259
1968	27	467	3,429	11,020

[1] Includes salt brine from Canada through the Detroit, Mich. customs district for 1967, 443,457 short tons valued at $128,839; 1968, 300,596 short tons valued at $89,187.

Table 13.—U.S. imports for consumption of salt, by customs district[1]

(Thousand short tons and thousand dollars)

Customs district	1967		1968	
	Quantity	Value	Quantity	Value
Baltimore, Md	179	$490	248	$831
Boston, Mass	92	369	149	674
Bridgeport, Conn	22	59	120	401
Buffalo, N.Y	52	225	25	109
Chicago, Ill	181	858	303	1,397
Cleveland, Ohio	190	806	138	584
Detroit, Mich	850	2,205	745	2,315
Duluth, Minn	43	161	34	128
Juneau, Alaska	-----	-----	(2)	10
Los Angeles, Calif	175	361	197	444
Milwaukee, Wis	85	392	138	595
New York City	46	162	186	464
Norfolk, Va	12	43	24	92
Ogdensburg, N.Y	(2)	4	1	5
Philadelphia, Pa	22	164	44	195
Portland, Me	127	635	281	1,076
Portland, Ore	137	171	181	227
Providence, R.I	26	77	(2)	1
St. Albans, Vt	13	55	45	190
San Francisco, Calif	-----	-----	(2)	(2)
San Juan, Puerto Rico	6	31	6	31
Savannah, Ga	157	579	195	723
Seattle, Wash	391	602	457	898
Wilmington, N.C	37	92	39	97
Total	2,843	8,541	3,456	11,487

[1] Includes salt brine from Canada through the Detroit, Mich., customs district for 1967, 443,457 short tons valued at $128,839; 1968, 300,596 short tons valued at $89,187.

[2] Less than ½ unit.

WORLD REVIEW

Australia.—The increasing demand in the Japanese market for salt has resulted in the development of more salt producing facilities. Present and future plans were reviewed in a recent article.[2]

Bahama Islands.—The Diamond Crystal Salt Company began shipments of solar salt from its solar evaporation facility to Long Island. The facility is expected to have a production capacity of 350,000 to 500,000 tons per year by 1972, and covers 24,000 acres. Two years are required from the initial intake of seawater to the final deposition of salt. Output will be sold to the chemical industry for caustic chlorine manufacture and to cities and States for snow removal.[3]

---

[2] Bureau of Mines. Mineral Trade Notes. V. 65, No. 3, March 1968, p. 36–39.

[3] Chemical & Engineering News. V. 46, No. 49, Nov. 18, 1968, p. 19.

Table 14.—World production of salt by countries

(Thousand short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada	3,989	4,584	4,492	5,362	4,888
Bahamas	370	[3] 463	[e] 441	1,102	[e] 1,000
Costa Rica	22	2	2	11	13
El Salvador	24	25	21	NA	NA
Guatemala	20	17	22	NA	NA
Honduras	[e] 11	[e] 11	[e] 11	25	25
Mexico	[r] 1,965	[r] 2,425	[r] 2,643	3,671	NA
Nicaragua	19	20	21	12	NA
Panama	12	12	10	NA	NA
United States (including Puerto Rico):					
Rock salt	8,554	9,810	10,080	11,661	12,461
Other salt:					
United States	23,069	24,877	26,383	27,285	28,813
Puerto Rico	5	8	11	12	32
South America:					
Argentina	433	[r] 844	[r] 985	903	NA
Brazil	831	1,323	1,447	1,146	1,693
Chile	104	110	224	461	927
Colombia:					
Rock salt	319	309	332	342	349
Other salt	56	56	89	175	NA
Ecuador [e]	39	39	39	NA	NA
Peru	147	152	191	155	NA
Venezuela	224	190	164	[e] 94	139
Europe:					
Austria	432	445	518	467	495
Bulgaria	90	138	[e] 138	[e] 138	[e] 127
Czechoslovakia	203	211	217	223	[e] 226
Denmark	---------	---------	28	110	163
France:					
Rock salt and salt from springs	3,573	3,663	[r] 3,750	3,825	[e] 3,417
Marine salt	872	1,241	[r] 1,170	1,698	[e] 1,653
Germany:					
East	2,291	2,083	2,106	[e] 2,204	[e] 2,205
West (marketable):					
Rock salt and brine salt	[r] 5,951	[r] 6,318	[r] 6,491	6,468	[e] 7,275
Marine salt	[r] 438	[r] 565	625	649	[e] 705
Greece	111	96	100	105	109
Italy:					
Rock salt and brine salt	[r] 2,245	[r] 2,349	[r] 2,337	2,841	[e] 2,866
Marine salt	[r] 902	[r] 1,166	[r] 1,258	1,303	[e] 1,433
Netherlands	1,759	1,882	2,047	2,123	2,660
Poland:					
Rock salt	728	743	840	915	1,068
Other salt	1,743	1,789	1,815	1,828	1,835
Portugal:					
Rock salt	98	99	108	125	[e] 154
Marine salt	256	451	[r] 283	354	[e] 331
Rumania	1,994	2,222	2,255	2,270	[e] 2,315
Spain:					
Rock salt	808	876	[r] 891	[e] 882	[e] 882
Marine salt [3]	1,313	1,171	[r] 1,043	[e] 1,102	[e] 1,102
Switzerland	201	254	[r] 202	238	[e] 248
U.S.S.R	11,133	10,472	[r] 10,251	11,684	[e] 12,125
United Kingdom:					
Rock salt	776	810	[r] 1,153	775	NA
Other salt	6,659	6,906	6,929	7,066	NA
Yugoslavia	203	192	182	185	197
Africa:					
Algeria	128	128	[e] 128	[e] 129	[e] 132
Angola	89	65	67	86	80
Cape Verde Islands	35	44	[r] 34	NA	NA
Chad, Republic of (including natron) [e]	8	11	11	9	NA
Ethiopia (including Eritrea) [4]	226	207	[r] 628	287	289
Ghana	34	30	40	40	[e] 32
Kenya	30	34	[r] 60	54	67
Libya	13	13	(5)	NA	NA
Malagasy Republic	[r] 25	[r] 13	[r] 14	15	8
Mali	NA	3	3	4	NA
Mauritius	4	4	4	4	4
Morocco	67	37	43	22	45
Mozambique	---------	33	29	42	NA
Senegal, Republic of (including Mauritania)	62	56	67	66	[e] 66
Somali Republic	7	6	(5)	NA	NA
South Africa, Republic of	331	365	346	349	377
South-West Africa:					
Rock salt	6	6	6	[e] 6	NA
Other salt	103	103	65	[e] 83	NA

See footnote at end of table.

Table 14.—World production of salt by countries—Continued

(Thousand short tons)

Commodity	1964	1965	1966	1967	1968 [p]
Africa—Continued					
Sudan	66	57	47	63	[e] 66
Tanzania	36	[r] 44	[r] 46	40	33
Tunisia (sales)	236	392	362	331	397
Uganda	3	3	2	NA	---------
United Arab Republic	744	545	691	[e] 694	NA
Asia:					
Afghanistan:					
Rock salt	14	20	22	[e] 34	[e] 44
Other salt	13	22	20		
Burma	140	146	130	148	151
Ceylon	57	86	71	83	108
China, mainland [e]	11,000	14,300	14,300	14,300	16,500
Cyprus	[r] NA	6	4	8	6
India (including Goa after 1964)	5,122	[r] 5,202	[r] 4,985	6,200	5,560
Indonesia	[r] NA	278	[e] 276	[e] 276	[e] 87
Iran [6]	243	248	[e] 248	285	[e] 303
Iraq [e] [7]	30	66	66	66	66
Israel	47	61	64	63	[e] 80
Japan	984	935	937	1,073	1,066
Jordan	22	22	14	13	18
Korea:					
North [e]	440	550	606	606	606
South	425	737	433	675	618
Kuwait	---------	8	4	4	4
Laos	[e] 3	3	4	[e] 3	[e] 3
Lebanon	22	26	28	[e] 33	[e] 33
Mongolia [e]	9	9	9	9	9
Pakistan:					
Rock salt	217	299	[r] 288	270	360
Other salt	214	246	[r] 229	492	629
Philippines	52	281	202	128	206
Ryukyu Islands	3	3	7	7	[e] 7
Southern Yemen	89	[r] 54	[r] 83	[e] 88	[e] 99
Syrian Arab Republic	18	23	[e] 22	[e] 22	[e] 22
Taiwan	664	617	453	571	343
Thailand [e]	209	207	220	121	165
Turkey:					
Rock salt	36	39	35	[e] 39	42
Other salt	355	505	279	[e] 331	584
Vietnam:					
North [e]	165	165	165	165	165
South	208	177	[e] 176	173	NA
Yemen	[e] 39	---------	[e] 94	[e] 110	[e] 94
Oceania:					
Australia	611	733	722	787	[e] 882
New Zealand	24	39	40	62	[e] 55
Total [8]	[r] 108,720	[r] 119,730	[r] 122,274	131,564	124,442

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Salt is produced in many other countries but quantities are relatively insignificant or reliable data not available.

[2] Exports.

[3] Includes an average annual production in the Canary Islands of 15,000 metric tons of marine salt.

[4] Year ended September 10 of year stated.

[5] Less than ½ unit.

[6] Year ended March 20 of year following that stated.

[7] Year ended March 31 of year following that stated.

[8] Total is of listed figures only.

Brazil.—The decline in salt output in 1967 to 1.1 million tons from 1.4 million tons in 1966 was blamed on poor production, handling, and loading methods.

In order to improve the country's salt industry, Decree Law 257 was issued to control the economic policy relating to salt. The Brazilian Salt Institute was abolished and the Executive Salt Commission was created under the Ministry of Commerce. The new commission's objectives are to organize and expand the domestic salt market, increase production using new processes and techniques, and develop reserve salt stocks.

The Government approved plans for two new ocean loading terminals in the northeast section of the country.[4]

Canada.—The Canadian Salt Co. began construction of a sodium chloride plant to extract salt from waste liquors obtained from the mining complex of Kalcium Potash Ltd. near Belle Plaine, Saskatchewan. The plant will have a capacity of 150,000 tons per year and solve the problem of the disposal of high salt concentration waste liquor which has caused considerable pollution and disposal problems in the past.[5]

---

[4] Bureau of Mines. Mineral Trade Notes. V. 66, No. 1, January 1969, pp. 27–28.

Germany, West.—Dow Chemical Europe S.A. began an exploratory salt drilling program near Slade in the State of Niedersachsen in order to delineate salt deposits for possible future chlorine based chemical production in Europe.[6]

Korea, South.—In 1967 slightly over 500,000 tons of salt were produced from about 30,000 acres of ponds by solar evaporation. Most of the country's producing facilities are located on the west coast adjoining the Yellow Sea where maximum tides reach 30 feet. The purity of the salt produced averages about 80 percent.[7]

TECHNOLOGY

A recent paper described the major Canadian salt deposits, with a short description of the industry's early history. The industry's progress in recent years was discussed along with a description of dry and solution mining of salt. The future potential of Canada's salt was assessed.[8]

Salt used for highway deicing penetrates the adjacent soil and is related to underground pipe corrosion. Increased salt concentration lowers the resistivity of the soil and usually increases the corrosive effect of the soil. Natural leaching causes concentration differences over narrow depths that can start galvanic cell corrosion. The corrosion can be controlled by construction procedures that provide a uniform and well-drained soil around underground pipes.[9]

---

[5] European Chemical News (London). V. 14, No. 336, July 12, 1969, p. 12.

[6] European Chemical News (London). V. 13, No. 334, June 28, 1968, p. 24.

[7] Bureau of Mines. Mineral Trade Notes. V. 65, No. 7, July 1968, p. 27.

[8] Canadian Mining & Metallurgical Bulletin. History and Significance of Salt in Canada. V. 61, No. 673, May 1968, p. 652–660.

[9] Journal of the American Water Works Association. Underground Corrosion and Salt Infiltration. V. 60, No. 3, March 1968, p. 345–356.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/11

Sand and Gravel

By Paul L. Allsman [1]

Sand and gravel production rose 1 percent in 1968, although the 918 million tons produced was still 17 million tons below the record tonnage of 1966. The value of output soared above $1 billion for the first time. The value of sand and gravel production was 4 percent higher than the 1967 value of $982 million.

Output from commercial operations increased 6 percent in 1968, but that from Government and contractor operations dropped 15 percent.

DOMESTIC PRODUCTION

The leading producing State in 1968 was California with 125 million tons, 14 percent of the total. This was followed by Michigan, Ohio, Illinois, Minnesota, and New York. Sand and gravel production was distributed as follows; 77 percent by commercial operators, 23 percent by Government-and-contractor. The trend since 1965 has been to increased production by commercial plants. Gravel represented 60 percent of the total production in 1968, the same as in 1967. In 1968, 88 percent of the sand and gravel was reported as processed, a growing trend in recent years.

The number of commercial sand and gravel plants decreased from 6,315 in 1967 to 6,296 in 1968. The number of plants producing over 1 million tons increased markedly from 55 in 1967 to 66 in 1968, as the supersized, more efficient plant and attendant automation often made modernization a profitable investment.

A trend toward larger or more completely integrated industrial complexes, which give producers more efficiency in operations, was illustrated by several modern plants. A new $10 million plant was to replace Kaiser Sand and Gravel Co.'s old Radum, Calif., gravel plant. The plant, with a capacity of 2,000 tons per hour, equivalent to 8 million tons per year, will produce 13 aggregate sizes.[2] The combination plant of Lebanon Crushed Stone, Inc., at Lebanon, N.H., produces both crushed stone and sand and gravel from alternate deposits, as needed. The company owns four sand and gravel plants, at Keene, Tilton, Compton, and Lebanon, plus four ready-mix concrete plants and concrete products plants.[3]

The trend toward portable plants continued to grow in 1968, as these plants give producers more flexibility in their operations. A portable sand dredging plant is used by the Dooley Sand Co., Inc., Statesville, N.C., and is transported on trailers between dredge locations. A ten-inch hydraulic dredge and stockpiling conveyor handle overburden, mud layers, and gravel runs.[4] Standard Materials Corp.'s new 300-ton-per-hour movable plant at Clinton, Ind., replaces three stationary plants. The plant sections are skid-mounted or housed in semitrailers.[5] Fisher Contracting Co., Phoenix, Ariz., produced up to 1,050 tons per hour of assorted gravel aggregates for a special freeway project with a rubber-mounted plant. Four portable units and a bottom-dump truck handled the job.[6]

High-grade silica for cement manufacture is supplied by the 200-ton-per-hour, Oro Grande, Calif., quarry of Vinnell Mining and Minerals Corp., for use throughout southern California.[7] The $500,000 Crestmore, Calif., plant of Pulverized Sand of

---

[1] Mineral specialist, Division of Mineral Studies.

[2] Pit and Quarry. New 2,000-TPH Operation To Replace Kaiser's Famous Radum Gravel Plant. V. 61, No. 5, November 1968, pp. 83–84, 105.

[3] Trauffer, Walter E. New Hampshire Plant Produces Both Crushed Stone and Sand and Gravel. Pit and Quarry, v. 60, No. 8, February 1968, pp. 82–96.

[4] Trauffer, Walter E. Portable Sand Dredge and Plant Serve Wide Area. Pit and Quarry, v. 61, No. 2, August 1968, pp. 108–110.

[5] Burkhardt, H. A. Movable Sand and Gravel Plant Meets Needs of Separate Areas. Pit and Quarry, v. 61, No. 6, December 1968, pp. 64–67.

[6] Roads and Streets. How To Crush 500,000 Tons in Nine Weeks. V. 111, No. 11, November 1968, pp. 32–34.

[7] Utley, Harry F. New Silica-Quartz Plant in California. Pit and Quarry, v. 61, No. 3, September 1968, pp. 112–114.

Table 1.—Sand and gravel sold or used by producers in the United States, by classes of operations and uses

(Thousand short tons and thousand dollars)

Class of operation and use	1967		1968	
	Quantity	Value	Quantity	Value
Construction:				
Building:				
Sand	147,250	$157,928	160,882	$177,736
Gravel	118,690	160,335	134,193	182,732
Paving:				
Sand	[r] 133,966	[r] 129,798	134,346	130,912
Gravel	[r] 357,906	[r] 350,991	336,907	338,897
Fill:				
Sand	42,246	26,163	38,640	28,205
Gravel	50,935	36,836	59,730	44,890
Railroad ballast:				
Sand	412	382	631	631
Gravel	1,865	1,719	2,417	1,988
Other:				
Sand	10,018	9,756	7,921	7,307
Gravel	13,086	15,043	9,895	11,507
Total construction [1]	[r] 876,374	[r] 888,951	885,562	919,805
Industrial sand:				
Unground:				
Glass	8,937	28,976	9,627	31,863
Molding	9,459	26,934	10,332	29,126
Grinding and polishing	639	1,482	551	1,411
Blast sand	1,147	6,442	1,179	6,679
Fire or furnace	496	1,127	470	1,115
Engine	816	1,751	832	1,907
Filtration	201	572	212	709
Oil hydrofrac	190	1,328	258	2,030
Other	1,948	6,260	2,166	6,809
Total [1]	23,833	74,872	25,627	81,649
Ground:[2]	1,490	10,983	1,348	11,733
Total industrial [1]	25,323	85,855	26,975	93,382
Miscellaneous gravel	5,348	6,942	5,202	7,149
Grand total [1]	[r] 907,045	[r] 981,748	917,739	1,020,336
Commercial:				
Sand	305,170	366,596	323,084	399,066
Gravel	362,431	411,768	387,850	449,868
Government-and-contractor:[3]				
Sand	[r] 54,045	[r] 43,286	46,311	34,107
Gravel	[r] 185,399	[r] 160,098	160,494	137,295

[r] Revised.

[1] Data may not add to totals shown because of independent rounding.

[2] See table 10 for breakdown by use.

[3] Approximate figures for operations by States, counties, municipalities, and other Government agencies under lease.

California, Inc., produces 50,000 tons of silica flour annually, which is used in autoclaved cement block manufacture. Precrushed quartz is obtained from the Oro Grande quarry.[8]

Descriptions were published of a number of important plant features during the year. Wingra Stone Co., Madison, Wis., produced sand and gravel and crushed gravel from 41 deposits using two portable crushing and screening plants.[9] Standardization of equipment and techniques was possible in eight similar gravel pits in Becker County, N.C.[10] Eugene Sand and Gravel Inc.'s, plant at Eugene, Oreg., produced ground and crushed gravel from diked-off river channels in the Willamette River. Full rehabilitation with tree cover of dredged areas is planned.[11]

---

[8] Utley, Harry F. Pulverized Sand of California. Pit and Quarry, v. 61, No. 5, November 1968, pp. 106–108.

[9] Trauffer, Walter E. Wisconsin Contractor-Aggregate Producer. Pit and Quarry, v. 60, No. 11, May 1968, pp. 176–178, 182.

[10] Rock Products. Standardization: Key to Becker County's Sand Gravel Operations. V. 71. No. 6, June 1968, pp. 53–59.

[11] Trauffer, Walter E. New Oregon Sand and Gravel Plant. Pit and Quarry, v. 61, No. 4, October 1968, pp. 66–72.

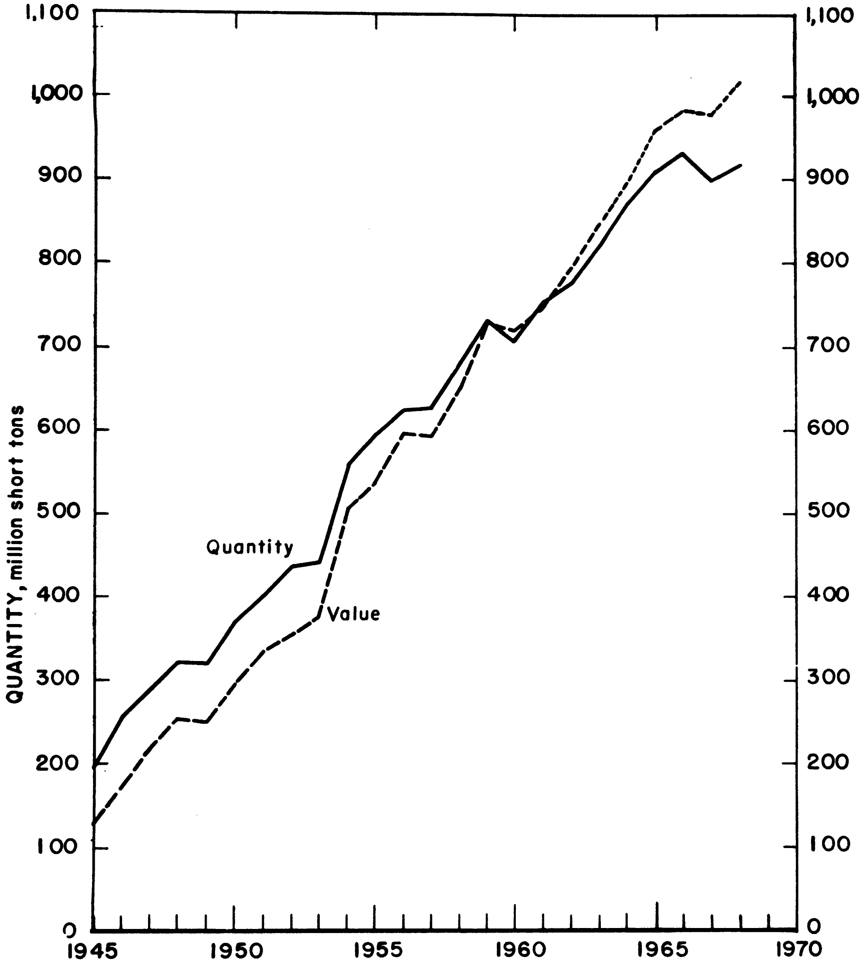

Figure 1.—Production and value of sand and gravel in the United States.

Yakima Cement Products Co., Yakima, Wash., dredges sand and gravel from an old river bed of the Yakima River. Many years of operation are foreseen in a channel at least 50 feet deep.[12] Nello L. Teer Co. of Durham, N.C., recently equipped a permanent pit to replace depleted areas and mobile plants to produce sand and gravel for its heavy construction contracts.[13]

---

[12] Trauffer, Walter E. Washington Gravel Firm Adjusts and Expands To Meet Changing Needs. Pit and Quarry, v. 60, No. 9, March 1968, pp. 98–103.

[13] Trauffer, Walter E. Nello L. Teer's "Permanent" Gravel Plant in New Location. Pit and Quarry, v. 60, No. 10, April 1968, pp. 92–95.

CONSUMPTION AND USES

The construction industry, the prime user of sand and gravel, consumed 96 percent of the tonnage and 90 percent by value of the sand and gravel output in 1968. The principal consumers of higher priced industrial sands are the foundry and glass industries. Forecasts for the coming year predicted an 8-percent rise in construction expenditures. Massive programs of urban reconstruction, plus a general upturn in prices, should carry all segments of the rock products industry to record production levels in 1969. New plant construction was swinging upward, and two of the largest gravel plants ever built were under construction on the west coast.[14]

New engineering techniques and the consequent economies possible in highway building revived chances for increased use of construction sand and gravel as road metal, fill, paving, and other highway uses. A new plant built for this growing demand, the 300-ton-per-hour plant of Fredericktown Sand and Gravel Co., Fredericktown, Ohio, is designed to meet any need for highway construction materials. A full range of State specifications or American Association of State Highway Officials gradations can be produced.[15] Thirty-seven percent of the total sand and gravel production was used for paving in 1968.

Important new uses are indicated for dielectric silica films produced by sputter-

---

[14] Rock Products. The Year Ahead: Sand and Gravel—A $1-Billion Year. V. 71, No. 12, December 1968, p. 62.

[15] Herod, Buren C. New Ohio Plant Reflects Progressive Management Ideas. Pit and Quarry, v. 60, No. 12, June 1968, pp. 108–113.

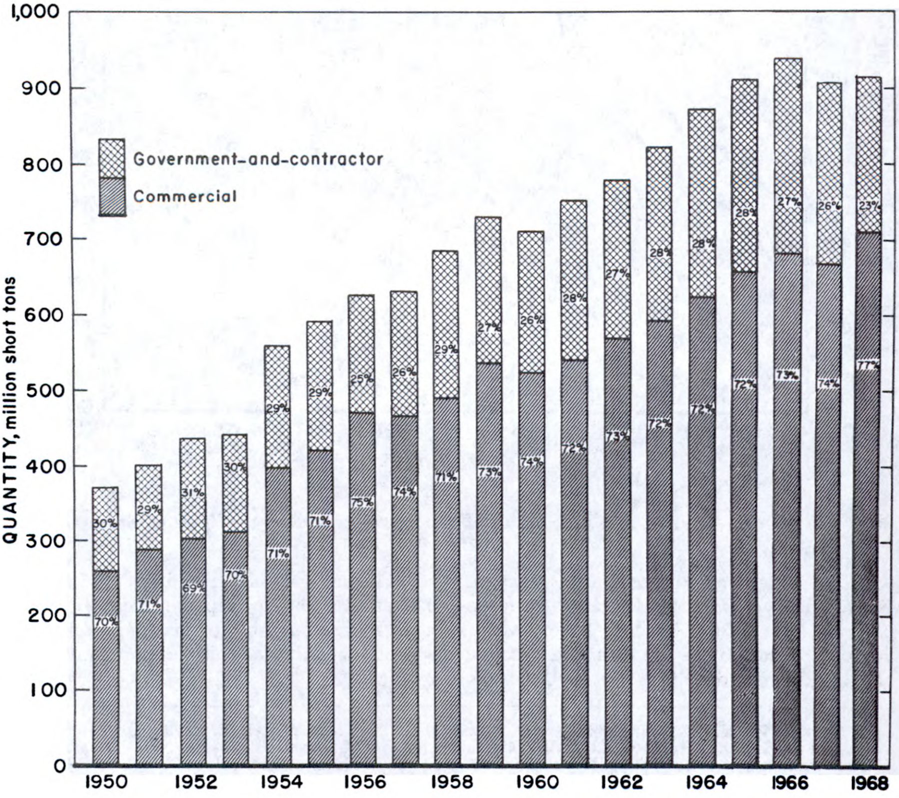

Figure 2.—Sand and gravel sold or used in the United States.

ing quartz in a gas plasma. Various dielectric properties of silica films and different depositional processes were studied in a series of experiments.[16] Bituminous base courses are a growing use for gravel in England. Gravel is preferred because it is cheaper. Experimental work by the Road Research Laboratory in design of flexible pavements was described.[17]

PRICES

Representative prices (carload lots) for construction sand and gravel in 20 metropolitan areas were published each month in Engineering News-Record. Prices for sand ranged from $4.30 per ton in Chicago to $1.57 per ton in Denver; the average price reported was $2.51 per ton. Prices for 1½-inch gravel ranged from $4.00 per ton in Los Angeles to $1.65 in Cincinnati; the average price reported for 16 major cities was $2.75 per ton. Prices for ¾-inch gravel ranged from $4.50 in Seattle to $1.65 in Cincinnati, and averaged $2.85 per ton for 19 cities. The average value of sand and gravel sold or used by producers, f.o.b. plant, was $1.11 per ton, compared with $1.08 per ton in 1967.

FOREIGN TRADE

In 1968, Canada received 82 percent of U.S. exports of sand, the Bahamas received 9 percent, and Mexico received 7 percent. Canada received 74 percent of U.S. exports of gravel, the Bahamas received 21 percent, and Norway and Mexico each received 2 percent. Total exports of sand were 2,048,450 short tons; gravel exports were 302,694 short tons.

All the crude sand and gravel imported in 1968 was from Canada; almost all the imported glass sand was from Australia.

WORLD REVIEW

Australia.—Cape Flattery Silica Mines Pty., Ltd., announced an export agreement to ship 340,000 short tons of silica to Japan over a 3-year period.

Canada.—Northern Silica, Ltd., of Regina, Saskatchewan, entered an agreement to explore 18 square miles of silica sand deposits near Hudson Bay. A $1 million processing plant and 10-mile rail spur are being planned. Industrial Minerals of Canada, Ltd., acquired the Georgian Bay, Ontario, silica plant of Union Carbide Canada, Ltd. A new open-pit silica mine and a new $1.5 million silica sand and flour grinding plant are planned. Use of sized sands for mine backfill was described at Noranda Mines, Ltd., in Ontario. Up to 3,000 tons of sandfill per day is used, along with some cement.[18]

Italy.—Cabot Italiana Sp.A. of Milan marketed CAB-O-SIL, a new fire-dried, fumed silica product developed in the United States. Montecatini-Edison planned development of silica glass sand deposits in Palermo Province.

Netherlands.—The City of Amsterdam put a new $18 million sand-desalting plant on stream. The plant floats on twin-pontooned catamarans, and it dredges and desalts sands from the North Sea. About 100 million cubic yards of fill sand will be needed in the next 10 years.[19]

South Africa, Republic of.—Robert Hudson and Sons obtained a franchise for a semiautomatic sand-lime brickmaking machine; silica sand is obtained from mine dumps on the Witwatersrand Reef. Kalksandsteen (Pty.), Ltd., erected the first new sand-lime brick plant.[20]

United Kingdom.—Metro-Greenham Aggregates, Ltd., dredges 4,000 tons of sand and gravel per day from the North Sea. Materials are processed into usable aggregates at the Nine Elms plant, Battersea, River Thames.[21]

---

[16] Pratt, I. H. Processing and Evaluation of RF Sputtered Quartz. Trans. AIME, v. 242, No. 3, March 1968, pp. 526–531.

[17] Please, A., and F. E. Mayer. Resistance to Plastic Flow of Bituminous Basecourses Made With Gravel Aggregates. Chem. and Ind. (London), No. 37, Sept. 14, 1968, pp. 1238–1245.

[18] Barnett, C. Preparation of Hydraulic Sand and Cement Backfill at Noranda Mines Ltd., Geco Division. Canadian Min. J., v. 89, No. 12, December 1968, p. 47.

[19] Engineering News-Record. Desalting Is Answer to Holland Sand Storage. V. 181, No. 26, Dec. 26, 1968, pp. 34–35.

[20] South African Mining and Engineering Journal. Automation in Manufacture of Pressed Bricks. V. 79, No. 3950, Oct. 18, 1968, p. 893.

[21] Cement, Lime, and Gravel. Processing Sea-dredged Aggregates in London. V. 43, No. 8, August 1968, pp. 243–246.

TECHNOLOGY

The National Sand and Gravel Association forecast greater efficiency in plant operations at its annual Controllers Conference in St. Paul, Minn. Producers were turning to computer systems, planning and control, and other modern management methods to cut costs.[22] An important study of urban planning of sand and gravel use was carried out by the Orange County, Calif., planning department. The study recommended full utilization, conservation, and optimum use of both the resource and the land, based on geologic engineering studies. Zoning regulations should set standards for noise, air pollution, dust, and land slope control. Reclaimed areas have been utilized for Government storage, chemical, and petroleum storage, outdoor theatres, golf ranges, tree farms, stadiums, race tracks, and lumber storage.[23]

The possible importance of offshore sand and gravel deposits in replacing depleted resources near urban centers was investigated for the northeastern United States. Continental Shelf deposits seem continuous, but they are largely unsampled.[24]

Results of research on silica sand mineralogy and products were published in 1968. The development of silica sand briquets as a substitute for quartzite, used in production of silicon metal, was described. Quartzite is in short supply in some areas.[25] Flotation experiments on milky-white quartz were described; long chained collectors proved effective. Flotation may allow upgrading of many promising quartz deposits as sources of silica sand.[26] Quartz sand mineralogy, thermal expansion, and elastic strains in whiteware bodies were examined by X-ray diffraction and differential thermal analysis. Physical properties of whiteware bodies, such as strength and tendency to crack, were determined.[27]

The new 158-inch-diameter, fused-silica, telescopic mirror of the Kitt Peak National Observatory, Tucson, Ariz., was fabricated in three layers. The manufacture of this blank represents a significant advance in the technology of telescope mirrors and of fused quartz glass.[28] High-quartz glasses containing traces of MgO, Li_20, or Al_2O_3 were examined by X-ray diffraction. At high temperatures the impurities were transformed to spinel, keatite, and cordierite.[29]

Use of the versatile dragline for underwater operations and removal of thick overburden was described for oolithic limestone sand deposits.[30] Applications of the dragscraper and the slackline cableway bucket to long range and deep underwater digging, at costs of 3 to 10 cents per cubic yard were given.[31] Heavy media separation in conjunction with screening and jigging was used to upgrade a glacial gravel deposit at Casco, Wis.[32]

Descriptions of several new mechanized sand and gravel plants were published, illustrating equipment technology. The 600-ton-per-hour plant of Antelope Valley Aggregates, Inc., Los Angeles County, Calif., is completely automatic with a system of 50 separate conveyor flights. Stacker belts, scalping screens, and a spiral sand dewaterer complete the mechanization.[33] Knoxville Sand and Gravel Co., Des Moines, Iowa, built its own power source, which has cut power costs by 70 percent and increased the operating season.[34]

---

[22] Stearn, Enid W. Tools for Greater Efficiency, Economy Laid Before NSGA Conference. Rock Prod., v. 71, No. 10, October 1968, pp. 98, 110.

[23] Young, Eleanor J. Urban Planning for Sand and Gravel Needs. Pit and Quarry v. 61, No. 6, December 1968, pp. 89–91.

[24] Schlee, John. Sand and Gravel on the Continental Shelf Off the Northeastern United States. U.S. Geol. Survey Circ. 602, 1968, 9 pp.

[25] Ehrlinger, H. P., M. L. Schroder, L. R. Camp, and H. W. Jackman. Silica Sand Briquets and Pellets as a Replacement for Quartzite. Illinois State Geol. Survey, Ind. Miner. Notes 32, March 1968, 8 pp.

[26] Ghigi, G. Flotation of Quartz With Some Polymer Complex Collectors. Bull. Inst. Min. & Met. (London), v. 77, No. 745, December 1968, pp. 212–219.

[27] Cucka, Paul, and R. F. Oliva. X-Ray Measurement of Strain in Quartz Particles of Whiteware Bodies. J. Am. Ceram. Soc., v. 51, No. 8, August 1968, pp. 458–464.

[28] Taeler, David H. 158-Inch Fused Quartz Mirror Blank. Ceram. Age, v. 84, No. 2, February 1968, pp. 36–39.

[29] Ray, S., and G. M. Muchow. High-Quartz Solid Solution Phases From Thermally Crystallized Glasses. J. Am. Ceram. Soc., v. 51, No. 12, Dec. 21, 1968, 678–682.

[30] Weirich, George. Handling Hard Rock With a Dragline. Rock Prod., v. 71, No. 12, December 1968, pp. 102, 104.

[31] Levine, Sidney. Don't Overlook Cable Powered Scrapers. Rock Prod., v. 71, No. 12, December 1968, pp. 80–83.

[32] Bergstrom, John H. HMS Helps Wisconsin Gravel Producer Protect Quality Image. Rock Prod., v. 71, No. 9, September 1968, pp. 115–117.

[33] Utley, Harry F. Aggregate Production Activity in Los Angeles County Explodes Into Nearby Antelope Valley. Pit and Quarry, v. 60, No. 12, June 1968, pp. 100–105.

[34] Rock Products. Sand and Gravel Producer Switches to Onsite Power, Cuts Costs 70 percent. V. 71, No. 6, June 1968, pp. 78–79.

Table 2.—Sand and gravel sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Sand		Gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1964	326,641	$358,129	541,567	$535,246	868,208	$893,375
1965	352,735	388,051	555,314	569,365	908,049	957,416
1966	368,321	408,757	566,160	576,225	934,481	984,982
1967 [r]	359,215	409,882	547,830	571,866	907,045	981,748
1968	369,395	433,173	548,344	587,163	917,739	1,020,336

[r] Revised.

Table 3.—Sand and gravel sold or used by producers in the United States, by States, and classes of operations

(Thousand short tons and thousand dollars)

State	1967						1968					
	Commercial		Government-and-contractor		Total [1]		Commercial		Government-and-contractor		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	7,227	$7,966	2	$3	7,229	$7,969	8,052	$9,024	88	$106	8,140	$9,130
Alaska	1,822	1,749	20,548	24,499	22,370	26,248	1,564	1,723	16,449	18,643	18,013	20,366
Arizona	8,232	9,281	[r] 10,231	[r] 9,128	[r] 18,463	[r] 18,409	9,267	9,890	4,714	4,527	13,981	14,423
Arkansas	10,202	13,113	4,037	2,414	14,239	15,531	10,682	12,795	2,315	1,848	12,997	14,643
California	95,694	117,182	20,431	22,028	116,125	189,212	100,495	129,841	24,160	23,517	124,655	163,360
Colorado	11,107	12,752	10,703	10,150	21,810	22,904	11,967	15,810	11,154	10,794	23,121	26,608
Connecticut	6,618	8,055	1,702	655	8,320	8,710	7,579	8,838	1,173	483	8,752	9,821
Delaware	1,966	1,846	---------	---------	1,966	1,846	1,596	1,483	---------	---------	1,596	1,483
Florida	6,578	6,256	334	222	6,912	6,479	7,640	7,890	125	77	7,765	7,967
Georgia	3,787	4,206	---------	---------	3,787	4,206	3,803	4,314	---------	---------	3,803	4,314
Hawaii	460	1,449	9	18	469	1,467	546	1,653	---------	---------	546	1,653
Idaho	2,145	2,212	9,101	9,278	11,246	11,490	2,162	2,839	6,062	6,294	8,224	9,133
Illinois	37,347	43,303	1,454	872	38,801	44,175	44,132	52,106	1,477	835	45,609	52,943
Indiana	25,340	25,049	925	540	26,265	25,588	24,856	25,636	918	524	25,774	26,160
Iowa	15,405	15,095	2,329	1,470	17,734	16,564	14,018	13,746	2,314	1,445	16,332	15,192
Kansas	8,510	6,727	3,556	1,922	12,066	8,650	10,267	8,953	2,160	1,608	12,427	10,559
Kentucky	7,507	7,562	474	297	7,981	7,859	7,349	7,944	129	137	7,478	8,081
Louisiana	20,216	27,346	96	96	20,312	27,442	20,208	26,354	203	150	20,411	26,504
Maine	2,076	1,858	9,551	3,509	11,627	5,368	2,764	2,270	9,102	3,711	11,866	5,978
Maryland	12,637	17,606	231	118	12,868	17,724	11,355	16,959	364	198	11,719	17,157
Massachusetts	14,727	16,552	3,154	2,950	17,881	19,504	14,386	16,934	3,413	3,171	17,799	20,106
Michigan	43,243	44,646	9,067	4,972	52,310	49,616	48,850	50,862	7,813	4,111	56,663	54,979
Minnesota	31,721	27,301	9,491	5,824	41,212	33,132	37,859	32,121	6,815	4,291	44,674	36,414
Mississippi	13,575	14,299	464	1,186	14,039	15,485	11,660	12,522	320	147	11,980	12,669
Missouri	9,651	12,488	65	68	9,716	12,556	10,597	14,153	52	51	10,649	14,204
Montana	2,794	2,985	9,545	7,669	12,339	10,655	2,432	2,886	6,330	4,867	8,762	7,754
Nebraska	10,621	9,856	1,118	1,021	11,739	10,878	12,055	12,332	958	842	13,013	13,175
Nevada	3,220	5,079	6,946	3,561	10,166	8,644	3,945	6,576	3,867	3,865	7,812	10,442
New Hampshire	3,607	3,295	4,842	1,843	8,449	5,137	4,449	4,350	3,293	1,350	7,742	5,698
New Jersey	18,610	29,969	16	6	18,626	29,975	20,306	33,570	---------	---------	20,306	33,570
New Mexico	3,145	4,109	11,527	10,228	14,672	14,336	3,523	4,832	8,739	7,563	12,262	12,396
New York	27,928	32,488	15,572	12,008	43,500	44,499	27,427	33,342	16,012	12,469	43,439	45,812
North Carolina	6,563	7,998	3,451	1,964	10,014	9,962	6,931	8,784	3,840	2,443	10,771	11,178
North Dakota	4,163	4,586	4,659	4,536	8,822	9,118	3,661	4,291	7,178	5,823	10,839	10,159
Ohio	42,817	52,743	379	145	43,196	52,888	46,162	57,404	572	267	46,734	57,671
Oklahoma	3,654	4,729	886	552	4,540	5,280	4,283	5,691	758	595	5,041	6,288
Oregon	10,551	12,600	9,079	12,647	19,630	25,250	12,485	14,546	5,775	6,910	18,260	21,457
Pennsylvania	17,427	29,535	52	79	17,479	29,614	18,011	30,839	90	237	18,101	31,076
Rhode Island	2,334	2,416	---------	---------	2,334	2,416	2,291	2,546	---------	---------	2,291	2,546
South Carolina	5,248	7,178	---------	---------	5,248	7,178	5,662	8,074	---------	---------	5,662	8,074

South Dakota	2,690	3,127	10,773	10,616	13,463	13,737	2,824	2,988	8,734	8,591	11,558	11,578
Tennessee	7,115	10,036	860	643	7,975	10,679	6,653	10,567	691	573	7,344	11,140
Texas	25,397	33,630	6,001	5,539	31,398	39,170	28,919	38,188	3,924	3,356	31,843	41,546
Utah	4,092	4,028	5,320	4,605	9,412	8,631	5,004	4,856	5,289	4,510	10,293	9,364
Vermont	1,384	1,355	2,334	822	3,718	2,178	2,314	2,294	1,273	510	3,587	2,806
Virginia	9,634	12,256	229	238	9,863	12,494	10,774	18,613	85	31	10,859	18,644
Washington	17,141	17,473	11,023	10,046	28,164	27,520	18,711	18,822	12,721	9,018	31,432	27,839
West Virginia	5,827	12,167	---------	---------	5,827	12,167	5,657	11,900	---------	---------	5,657	11,900
Wisconsin	32,696	27,551	9,846	5,401	42,542	32,955	29,220	24,849	10,587	6,058	39,807	30,908
Wyoming	1,150	1,276	7,031	6,976	8,181	8,253	4,581	4,189	4,769	4,789	9,350	8,978
Total [1]	667,601	778,364	[r] 239,444	[r] 203,362	[r] 907,045	[r] 981,748	710,934	848,934	206,805	171,327	917,739	1,020,336
American Samoa	---------	---------	7	7	7	7	---------	---------	20	19	20	19
Panama Canal Zone	56	94	---------	---------	56	94	55	77	---------	---------	55	77
Puerto Rico	12,747	20,074	1,354	1,558	14,101	21,633	14,250	22,655	1,896	2,066	16,146	24,723

[r] Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 4.—Sand and gravel sold or used by producers in the United States in 1968, by States, uses, and classes of operation

(Thousand short tons and thousand dollars)

State	Sand, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,306	$2,439	-------	-------	908	$921	8	$12
Alaska	49	220	105	$96	29	63	615	759
Arizona	2,917	3,164	401	401	604	586	620	595
Arkansas	1,144	1,402	1	1	2,441	2,354	466	361
California	21,904	27,926	40	50	13,993	16,913	7,550	6,863
Colorado	2,821	2,605	1	1	628	1,573	1,365	1,373
Connecticut	2,054	2,306	-------	-------	1,630	2,035	183	72
Delaware	296	354	-------	-------	316	309	-------	-------
Florida	6,267	5,263	-------	-------	W	W	W	W
Georgia	2,989	2,785	-------	-------	439	331	-------	-------
Hawaii	402	1,295	-------	-------	25	47	-------	-------
Idaho	308	584	-------	-------	96	168	1,770	944
Illinois	8,191	7,993	-------	-------	7,130	6,288	448	249
Indiana	4,588	4,058	-------	-------	4,422	3,974	58	31
Iowa	2,995	3,090	1	(1)	2,606	2,618	85	49
Kansas	3,753	3,086	-------	-------	3,489	3,068	1,316	950
Kentucky	2,733	2,869	-------	-------	1,390	1,433	-------	-------
Louisiana	4,988	5,027	-------	-------	2,129	2,135	-------	-------
Maine	267	239	-------	-------	331	321	410	164
Maryland	4,459	6,443	-------	-------	1,273	1,967	182	105
Massachusetts	2,897	3,414	-------	-------	2,480	2,661	45	34
Michigan	7,475	6,481	-------	-------	6,704	5,585	1,839	845
Minnesota	4,766	4,189	-------	-------	2,824	2,072	1,176	726
Mississippi	2,173	2,002	-------	-------	1,844	1,750	-------	-------
Missouri	3,949	3,581	-------	-------	1,304	1,456	-------	-------
Montana	285	518	-------	-------	120	215	1,118	676
Nebraska	2,592	2,400	-------	-------	961	881	181	181
Nevada	687	1,441	-------	-------	280	282	88	95
New Hampshire	673	592	-------	-------	607	554	1,225	488
New Jersey	5,955	6,001	-------	-------	4,266	4,598	-------	-------
New Mexico	708	909	65	65	448	518	73	93
New York	9,630	12,211	98	146	3,216	4,326	690	474
North Carolina	2,868	2,676	-------	-------	686	821	2,381	1,434
North Dakota	355	423	-------	-------	206	189	3,314	3,039
Ohio	7,061	8,446	-------	-------	9,520	9,797	W	W
Oklahoma	1,874	1,894	71	91	927	888	311	195
Oregon	1,485	1,919	2	1	301	478	214	131
Pennsylvania	5,420	8,296	-------	-------	3,433	5,843	-------	-------
Rhode Island	592	738	-------	-------	185	183	-------	-------
South Carolina	2,854	1,874	-------	-------	W	W	-------	-------
South Dakota	456	498	1	1	118	139	1,738	1,736
Tennessee	2,470	3,767	1	1	1,032	1,680	22	37
Texas	5,788	6,330	19	24	4,284	4,493	280	249
Utah	799	876	12	12	352	395	1,108	1,080
Vermont	298	270	-------	-------	474	377	361	127
Virginia	2,552	3,006	-------	-------	2,948	2,848	26	9
Washington	2,981	3,115	-------	-------	869	914	155	129
West Virginia	1,717	2,258	-------	-------	482	781	-------	-------
Wisconsin	3,583	3,311	-------	-------	3,460	2,277	1,935	947
Wyoming	189	259	1	3	113	173	1,952	1,948
Undistributed	-------	-------	-------	-------	528	337	242	97
Total	160,063	176,843	819	893	98,796	103,615	35,550	27,297
American Samoa	-------	-------	20	19	-------	-------	-------	-------
Panama Canal Zone	-------	-------	-------	-------	-------	-------	-------	-------
Puerto Rico	3,269	6,554	4	8	3,032	3,678	565	803

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."
[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1968, by States, uses, and classes of operation—Continued

(Thousand short tons and thousand dollars)

State	Sand, construction—Continued									
	Railroad ballast (commercial)		Fill				Other [2]			
			Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	68	$22	-----	-----	W	W	-----	-----
Alaska	-----	-----	32	57	808	$418	3	$14	-----	-----
Arizona	W	W	630	182	70	68	W	W	-----	-----
Arkansas	-----	-----	164	100	-----	-----	W	W	-----	-----
California	42	$63	3,779	2,819	1,030	1,017	741	801	36	$37
Colorado	W	W	142	100	101	101	W	W	16	14
Connecticut	-----	-----	413	246	30	20	W	W	27	16
Delaware	-----	-----	W	W	-----	-----	W	W	-----	-----
Florida	-----	-----	W	W	81	50	W	W	-----	-----
Georgia	-----	-----	36	31	-----	-----	-----	-----	-----	-----
Hawaii	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	-----	-----	14	19	-----	-----	16	37	17	21
Illinois	W	W	W	W	343	163	W	W	-----	-----
Indiana	W	W	1,880	1,201	4	2	W	W	-----	-----
Iowa	W	W	1,216	768	41	20	W	W	4	1
Kansas	2	W	884	444	23	18	72	59	-----	-----
Kentucky	-----	-----	1,449	1,132	-----	-----	2	3	-----	-----
Louisiana	-----	-----	62	59	-----	-----	W	W	-----	-----
Maine	-----	-----	432	155	-----	-----	98	74	120	41
Maryland	-----	-----	W	W	-----	-----	W	W	-----	-----
Massachusetts	-----	-----	608	287	-----	-----	W	W	11	10
Michigan	W	W	3,956	1,743	747	310	W	W	151	58
Minnesota	-----	-----	707	332	57	25	W	W	17	8
Mississippi	-----	-----	W	W	-----	-----	163	156	-----	-----
Missouri	W	W	338	326	-----	-----	32	42	-----	-----
Montana	-----	-----	18	27	264	168	3	5	284	427
Nebraska	-----	-----	690	620	8	4	15	17	-----	-----
Nevada	-----	-----	143	113	8	5	145	259	24	24
New Hampshire	-----	-----	834	579	18	6	45	31	-----	-----
New Jersey	-----	-----	1,401	675	-----	-----	81	91	-----	-----
New Mexico	2	1	30	21	-----	-----	-----	-----	3	2
New York	-----	-----	1,113	439	3,070	1,280	684	701	692	333
North Carolina	W	W	126	122	259	165	2	2	545	173
North Dakota	-----	-----	166	179	5	5	2	3	-----	-----
Ohio	-----	-----	1,478	1,141	26	9	361	301	-----	-----
Oklahoma	W	W	345	201	-----	-----	243	192	8	6
Oregon	W	W	489	386	1	1	67	83	181	191
Pennsylvania	-----	-----	28	38	-----	-----	W	W	67	171
Rhode Island	-----	-----	167	75	-----	-----	W	W	-----	-----
South Carolina	-----	-----	W	W	-----	-----	-----	-----	-----	-----
South Dakota	-----	-----	58	65	1	1	-----	-----	11	6
Tennessee	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Texas	W	W	879	643	10	5	484	546	1	1
Utah	W	W	83	36	50	25	W	W	19	17
Vermont	-----	-----	55	19	-----	-----	W	W	41	20
Virginia	139	56	357	215	41	14	44	50	-----	-----
Washington	W	W	709	362	23	18	123	146	216	292
West Virginia	-----	-----	W	W	-----	-----	W	W	-----	-----
Wisconsin	W	W	1,525	779	208	79	29	14	124	51
Wyoming	-----	-----	W	W	-----	-----	W	W	-----	-----
Undistributed	446	511	3,809	2,450	-----	-----	1,851	1,760	-----	-----
Total	631	631	31,313	19,208	7,327	3,997	5,306	5,387	2,615	1,920
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	55	77	-----	-----
Puerto Rico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[2] Includes unspecified.

Table 4.—Sand and gravel sold or used by producers in the United States in 1968, by States, uses, and classes of operation—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)									
	Glass		Molding		Grinding and polishing		Blast		Fire or furnace	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	-----	-----	W	W	-----	-----	-----	-----	W	W
Alaska	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arizona	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Arkansas	W	W	W	W	---	-----	W	W	-----	-----
California	1,073	$5,103	58	$272	-----	-----	276	$1,294	W	W
Colorado	-----	-----	-----	-----	-----	-----	W	W	W	W
Connecticut	-----	-----	(1)	1	-----	-----	-----	-----	-----	-----
Delaware	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Florida	W	W	W	W	-----	-----	W	W	-----	-----
Georgia	W	W	W	W	-----	-----	W	W	-----	-----
Hawaii	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Idaho	W	W	-----	-----	-----	-----	W	W	-----	-----
Illinois	2,059	4,618	1,038	3,749	W	W	W	W	-----	-----
Indiana	W	W	W	W	-----	-----	-----	-----	W	W
Iowa	-----	-----	W	W	-----	-----	W	W	-----	-----
Kansas	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Kentucky	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Louisiana	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Maine	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Maryland	W	W	-----	-----	W	W	-----	-----	-----	-----
Massachusetts	-----	-----	W	W	-----	-----	7	65	-----	-----
Michigan	W	W	4,129	7,637	-----	-----	(1)	W	-----	-----
Minnesota	W	W	W	W	-----	-----	W	W	-----	-----
Mississippi	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Missouri	548	1,493	44	130	W	W	W	W	-----	-----
Montana	-----	-----	-----	-----	-----	-----	2	3	-----	-----
Nebraska	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nevada	W	W	W	W	-----	-----	-----	-----	W	W
New Hampshire	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
New Jersey	1,123	4,579	1,857	6,322	-----	-----	184	713	W	W
New Mexico	-----	-----	-----	-----	-----	-----	1	2	-----	-----
New York	-----	-----	145	707	-----	-----	-----	-----	-----	-----
North Carolina	-----	-----	-----	-----	-----	-----	W	W	-----	-----
North Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ohio	W	W	432	2,017	-----	-----	W	W	W	W
Oklahoma	W	W	W	W	-----	-----	W	W	-----	-----
Oregon	-----	-----	-----	-----	-----	-----	12	7	-----	-----
Pennsylvania	W	W	142	421	W	W	W	W	50	171
Rhode Island	-----	-----	W	W	-----	-----	-----	-----	-----	-----
South Carolina	W	W	W	W	-----	-----	13	62	W	W
South Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee	W	W	304	1,044	W	W	W	W	W	W
Texas	W	W	139	365	-----	-----	W	W	W	W
Utah	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Vermont	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Virginia	360	1,043	-----	-----	-----	-----	-----	-----	-----	-----
Washington	W	W	-----	-----	-----	-----	W	W	-----	-----
West Virginia	W	W	W	W	-----	-----	W	W	34	43
Wisconsin	W	W	812	2,209	-----	-----	34	125	-----	-----
Wyoming	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Undistributed	4,464	15,027	1,232	4,252	551	1,411	700	4,408	386	901
Total	9,627	31,863	10,332	29,126	551	1,411	1,179	6,679	470	1,115
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	-----	-----	-----	-----	-----	-----	-----	----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1968, by States, uses, and classes of operation—Continued

(Thousand short tons and thousand dollars)

State	Sand, industrial (commercial)—Continued									
	Engine		Filtration		Oil (hydrafrac)		Other		Ground sand	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	-----	-----	-----	-----	W	W	-----	-----
Alaska	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Arizona	(1)	$12	-----	-----	W	W	-----	-----	-----	-----
Arkansas	W	W	-----	-----	-----	-----	W	W	W	W
California	64	185	W	W	(1)	W	76	$331	59	$440
Colorado	W	W	W	W	-----	-----	-----	-----	-----	-----
Connecticut	-----	-----	W	W	-----	-----	-----	-----	-----	-----
Delaware	2	1	-----	-----	-----	-----	-----	-----	-----	-----
Florida	W	W	W	W	-----	-----	W	W	W	W
Georgia	W	W	W	W	-----	-----	W	W	W	W
Hawaii	-----	-----	-----	-----	-----	-----	4	18	-----	-----
Idaho	-----	-----	W	W	-----	-----	(1)	W	W	W
Illinois	W	W	W	W	W	W	W	W	W	W
Indiana	W	W	-----	-----	-----	-----	W	W	W	W
Iowa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Kansas	22	34	-----	-----	W	W	W	W	7	6
Kentucky	8	10	-----	-----	-----	-----	W	W	W	W
Louisiana	W	W	W	W	W	W	-----	-----	W	W
Maine	W	W	-----	-----	-----	-----	(1)	W	-----	-----
Maryland	-----	-----	-----	-----	-----	-----	W	W	-----	-----
Massachusetts	-----	-----	8	$16	-----	-----	-----	-----	-----	-----
Michigan	W	W	-----	-----	-----	-----	W	W	W	W
Minnesota	W	W	-----	-----	W	W	-----	-----	W	W
Mississippi	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Missouri	W	W	W	W	-----	-----	W	W	W	W
Montana	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Nebraska	-----	-----	-----	-----	-----	-----	1	1	-----	-----
Nevada	-----	-----	-----	-----	-----	-----	W	W	-----	-----
New Hampshire	W	W	W	W	-----	-----	-----	-----	-----	-----
New Jersey	W	W	W	W	-----	-----	184	877	138	1,313
New Mexico	3	2	-----	-----	-----	-----	-----	-----	-----	-----
New York	W	W	42	63	-----	-----	W	W	W	W
North Carolina	-----	-----	W	W	-----	-----	-----	-----	-----	-----
North Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Ohio	W	W	W	W	-----	-----	W	W	W	W
Oklahoma	-----	-----	-----	-----	-----	-----	W	W	W	W
Oregon	W	W	-----	-----	-----	-----	W	W	-----	-----
Pennsylvania	W	W	W	W	-----	-----	148	424	W	W
Rhode Island	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
South Carolina	W	W	W	W	-----	-----	W	W	99	687
South Dakota	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Tennessee	W	W	-----	-----	-----	-----	W	W	W	W
Texas	W	W	W	W	W	W	222	423	W	W
Utah	W	W	-----	-----	-----	-----	-----	-----	W	W
Vermont	W	W	-----	-----	-----	-----	-----	-----	-----	-----
Virginia	W	W	(1)	W	-----	-----	W	W	W	W
Washington	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
West Virginia	W	W	(1)	W	-----	-----	W	W	W	W
Wisconsin	W	W	W	W	W	W	W	W	(1)	W
Wyoming	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Undistributed	733	1,663	162	630	258	$2,030	1,531	4,735	1,045	9,287
Total	832	1,907	212	709	258	2,030	2,166	6,809	1,348	11,733
American Samoa	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Panama Canal Zone	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Puerto Rico	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

---

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Less than ½ unit.

Table 4.—Sand and gravel sold or used by producers in the United States in 1968, by States, uses, and classes of operation—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction							
	Building				Paving			
	Commercial		Government-and-contractor		Commercial		Government-and-contractor	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	2,219	$2,996	-------	-------	1,129	$1,260	80	$94
Alaska	63	218	562	$461	134	289	1,086	1,278
Arizona	2,269	2,951	600	601	1,510	1,888	2,908	2,756
Arkansas	1,263	2,087	2	2	5,135	5,685	1,650	1,386
California	25,335	33,214	44	48	30,418	37,419	10,513	12,309
Colorado	2,555	3,699	-------	-------	5,427	6,779	8,677	8,632
Connecticut	1,504	2,446	-------	-------	886	1,039	835	306
Delaware	147	201	-------	-------	704	534	-------	-------
Florida	W	W	-------	-------	-------	-------	-------	-------
Georgia	W	W	-------	-------	-------	-------	-------	-------
Hawaii	111	283	-------	-------	4	10	-------	-------
Idaho	480	658	4	7	1,057	1,086	3,747	4,987
Illinois	9,113	9,022	11	6	10,993	12,256	674	418
Indiana	3,369	4,253	-------	-------	7,770	8,628	849	487
Iowa	1,263	2,180	-------	-------	5,600	4,569	2,182	1,376
Kansas	259	238	-------	-------	1,673	1,742	820	638
Kentucky	755	940	-------	-------	W	W	129	137
Louisiana	8,575	11,321	-------	-------	4,042	6,485	203	150
Maine	174	170	-------	-------	931	1,026	8,567	3,501
Maryland	2,587	4,522	-------	-------	1,302	1,996	182	93
Massachusetts	2,801	4,470	-------	-------	3,064	3,589	3,354	3,124
Michigan	6,425	9,727	21	11	18,666	16,915	4,753	2,759
Minnesota	3,664	6,300	-------	-------	23,951	17,123	5,420	3,475
Mississippi	2,593	2,770	-------	-------	4,426	5,177	320	147
Missouri	2,127	2,730	-------	-------	1,716	2,070	52	51
Montana	503	766	13	5	1,090	913	3,853	2,554
Nebraska	1,227	1,263	-------	-------	6,098	6,641	769	658
Nevada	837	1,451	-------	-------	1,088	1,284	3,617	3,618
New Hampshire	822	1,108	-------	-------	1,013	1,153	2,050	854
New Jersey	2,785	5,142	-------	-------	1,713	2,271	-------	-------
New Mexico	915	1,496	124	155	1,374	1,849	8,440	7,229
New York	4,693	7,166	-------	-------	4,531	5,234	6,552	7,143
North Carolina	1,172	2,057	-------	-------	1,425	1,724	655	672
North Dakota	441	899	28	28	2,131	2,375	3,830	2,795
Ohio	8,301	10,141	-------	-------	14,930	19,412	235	141
Oklahoma	137	282	3	5	47	79	365	300
Oregon	2,957	3,442	219	289	5,934	7,172	2,754	4,079
Pennsylvania	3,599	5,921	-------	-------	3,367	5,324	3	7
Rhode Island	590	813	-------	-------	325	387	-------	-------
South Carolina	W	W	-------	-------	W	W	-------	-------
South Dakota	220	319	-------	-------	1,795	1,803	6,983	6,847
Tennessee	692	968	-------	-------	1,426	1,358	618	485
Texas	7,807	11,369	25	32	6,788	9,114	3,547	3,026
Utah	1,074	1,012	154	181	2,051	2,061	3,653	3,045
Vermont	409	586	15	3	519	637	856	362
Virginia	1,806	3,152	-------	-------	1,934	2,769	18	8
Washington	4,429	4,917	2	2	6,917	6,947	5,544	4,383
West Virginia	1,372	1,808	-------	-------	894	1,409	-------	-------
Wisconsin	4,074	3,853	-------	-------	13,754	11,167	7,767	4,698
Wyoming	198	280	3	5	2,240	2,530	2,783	2,800
Undistributed	1,652	3,284	-------	-------	1,092	1,916	-------	-------
Total	132,363	180,891	1,830	1,841	215,014	235,094	121,893	103,803
American Samoa	-------	-------	-------	-------	-------	-------	-------	-------
Panama Canal Zone	-------	-------	-------	-------	-------	-------	-------	-------
Puerto Rico	2,798	5,336	5	10	3,352	5,488	338	468

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

Table 4.—Sand and gravel sold or used by producers in the United States in 1968, by States, uses, and classes of operation—Continued

(Thousand short tons and thousand dollars)

State	Gravel, construction—Continued										Gravel miscellaneous (commercial)	
	Railroad ballast (commercial)		Fill				Other					
			Commercial		Government-and-contractor		Commercial		Government-and-contractor			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	W	W	W	W	-----	------	W	W	----	----	W	W
Alaska	7	$5	1,246	$854	13,273	$15,636	----	-----	----	----	1	$3
Arizona	W	W	1,174	707	115	112	W	W	----	----	W	W
Arkansas	----	----	130	105	196	98	W	W	----	----	W	W
California	85	102	1,213	1,170	4,802	3,040	1,056	$1,225	145	$155	313	520
Colorado	97	180	312	254	985	671	290	346	9	6	95	112
Connecticut	1	1	712	342	98	69	53	56	----	----	140	189
Delaware	----	----	80	30	-----	------	W	W	----	----	W	W
Florida	----	----	-----	-----	-----	------	----	-----	----	----	----	----
Georgia	----	----	W	W	-----	------	----	-----	----	----	----	----
Hawaii	----	----	-----	-----	-----	------	----	-----	----	----	----	----
Idaho	W	W	123	131	288	170	54	80	236	165	----	----
Illinois	152	157	1,357	934	1	1	11	11	----	----	----	----
Indiana	W	W	2,062	1,359	7	4	W	W	----	----	----	----
Iowa	W	W	W	W	1	(1)	----	-----	----	----	----	----
Kansas	----	----	10	12	1	(1)	51	167	----	----	33	59
Kentucky	39	55	154	139	-----	------	----	-----	----	----	W	W
Louisiana	----	----	177	250	-----	------	W	W	----	----	----	----
Maine	W	W	284	125	5	2	W	W	----	----	W	W
Maryland	----	----	W	W	-----	------	----	-----	----	----	W	W
Massachusetts	21	22	920	551	W	W	120	200	W	W	769	615
Michigan	W	W	393	293	301	134	W	W	1	(1)	----	----
Minnesota	405	252	954	426	142	58	10	12	3	1	----	----
Mississippi	57	28	W	W	-----	------	204	297	----	----	114	155
Missouri	----	----	33	19	-----	------	2	2	----	----	97	113
Montana	127	139	204	151	209	175	80	149	589	863	----	----
Nebraska	W	W	177	210	-----	------	W	W	----	----	263	271
Nevada	3	6	358	335	36	30	6	16	94	94	247	485
New Hampshire	----	----	156	77	-----	------	47	44	----	----	246	204
New Jersey	----	----	330	256	-----	------	W	W	----	----	W	W
New Mexico	----	----	27	16	29	16	1	1	5	3	14	17
New York	W	W	2,541	1,545	4,853	3,072	W	W	57	22	348	375
North Carolina	W	W	W	W	-----	------	W	W	----	----	W	W
North Dakota	174	59	126	98	1	1	----	-----	----	----	60	66
Ohio	W	W	2,163	1,362	W	W	W	W	W	W	423	590
Oklahoma	----	----	W	W	-----	--	W	W	----	----	----	----
Oregon	W	W	704	462	109	68	414	461	2,295	2,151	----	----
Pennsylvania	W	W	373	214	-----	------	115	116	20	59	W	W
Rhode Island	----	----	159	129	-----	------	W	W	----	----	W	W
South Carolina	W	W	W	W	-----	------	----	-----	----	----	----	----
South Dakota	----	----	139	110	-----	------	----	-----	----	----	43	54
Tennessee	W	W	30	22	50	50	W	W	----	----	W	W
Texas	----	----	338	261	42	26	575	948	----	----	12	19
Utah	15	6	442	225	292	147	----	-----	1	1	78	79
Vermont	----	----	518	374	-----	------	W	W	----	----	W	W
Virginia	----	----	W	W	-----	------	W	W	----	----	W	W
Washington	W	W	1,885	1,208	6,371	3,771	584	658	410	422	----	----
West Virginia	W	W	W	W	-----	------	----	-----	----	----	----	----
Wisconsin	192	114	1,672	852	553	279	12	9	----	----	----	----
Wyoming	446	162	1,289	660	30	28	5	6	----	----	81	94
Undistributed	596	700	1,928	943	47	21	2,271	2,731	69	30	1,825	3,129
Total	2,417	1,988	26,893	17,211	32,837	27,679	5,961	7,535	3,934	3,972	5,202	7,149
American Samoa	----	----	-----	-----	-----	------	----	-----	----	----	----	----
Panama Canal Zone	----	----	-----	-----	-----	------	----	-----	----	----	----	----
Puerto Rico	----	----	785	679	360	257	----	-----	----	----	----	----

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Less than ½ unit.

Table 5.—Sand and gravel sold or used by Government-and-contractor producers in the United States, by uses

(Thousand short tons and thousand dollars)

Year	Sand							
	Building		Paving		Fill		Other	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1964	950	$1,401	34,262	$26,999	6,335	$2,935	1,811	$882
1965	816	328	37,460	29,695	14,824	7,112	2,722	2,038
1966	808	943	37,087	29,702	12,920	8,430	1,663	927
1967	660	800	[r] 38,900	[r] 31,913	11,747	8,737	2,738	1,836
1968	819	893	35,550	27,297	7,327	8,997	2,615	1,920

Year	Gravel								Total Government-and-contractor sand and gravel [1]	
	Building		Paving		Fill		Other			
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1964	3,515	$3,946	163,872	$139,297	35,870	$18,030	772	$551	247,387	$194,041
1965	1,297	1,028	149,111	133,800	45,143	35,410	1,292	1,347	252,165	210,758
1966	2,869	3,131	158,709	134,180	39,298	29,268	1,530	1,441	254,884	208,022
1967	863	1,074	[r] 154,017	[r] 133,462	26,145	21,500	4,374	4,062	[r] 239,444	[r] 203,362
1968	1,830	1,841	121,893	103,803	32,837	27,679	3,934	3,972	206,805	171,327

[r] Revised.

[1] Data may not add to totals shown because of independent rounding.

Table 6.—Sand and gravel sold or used by Government-and-contractor producers in the United States, by types of producer

(Thousand short tons and thousand dollars)

Type of producer	1964		1965		1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Construction and maintenance crews	64,820	$41,451	62,822	$39,611	67,163	$43,821	68,655	$44,903	62,939	$42,146
Contractor	182,567	152,590	189,343	171,147	187,721	164,201	[r] 170,789	[r] 158,477	143,866	129,176
Total [1]	247,387	194,041	252,165	210,758	254,884	208,022	[r] 239,444	[r] 203,362	206,805	171,327
States	157,136	130,651	159,758	144,287	150,304	131,921	[r] 149,843	[r] 135,372	125,627	108,980
Counties	60,764	41,151	59,730	40,987	60,966	41,973	60,004	41,390	53,087	38,408
Municipalities	3,363	2,500	3,278	2,343	2,916	2,576	3,001	2,202	4,200	3,208
Federal agencies	26,124	19,739	29,399	23,141	40,698	31,552	26,596	24,398	23,891	20,731
Total [1]	247,387	194,041	252,165	210,758	254,884	208,022	[r] 239,444	[r] 203,362	206,805	171,327

[r] Revised.

[1] Data may not add to totals shown because of independent rounding.

Table 7.—Sand and gravel sold or used by producers in the United States by classes of operation and degree of preparation

(Thousand short tons and thousand dollars)

	1967		1968	
	Quantity	Value	Quantity	Value
Commercial operations:				
Prepared	609,039	$743,462	649,825	$810,246
Unprepared	58,562	34,902	61,109	38,688
Total [1]	667,601	778,364	710,934	848,934
Government-and-contractor operations:				
Prepared	[r] 181,120	[r] 160,841	160,663	137,922
Unprepared	[r] 58,324	[r] 42,539	46,142	33,407
Total [1]	[r] 239,444	[r] 203,380	206,805	171,327
Grand total [1]	[r] 907,045	[r] 981,726	917,739	1,020,336

[r] Revised.
[1] Data may not add to totals shown because of independent rounding.

Table 8.—Number and production of domestic commercial sand and gravel plants, by size of operation

Annual production (short tons)	1967				1968			
	Plants [1]		Production		Plants [1]		Production	
	Number	Percent of total	Thousand short tons	Percent of total	Number	Percent of total	Thousand short tons	Percent of total
Less than 25,000	2,609	41.3	26,032	3.9	2,404	38.2	25,361	3.6
25,000 to 50,000	949	15.0	35,164	5.3	1,026	16.3	38,263	5.4
50,000 to 100,000	1,016	16.1	74,142	11.1	1,039	16.5	76,197	10.7
100,000 to 200,000	804	12.7	115,065	17.2	854	13.5	122,397	17.2
200,000 to 300,000	400	6.3	96,901	14.5	420	6.7	102,490	14.4
300,000 to 400,000	201	3.2	69,570	10.4	168	2.7	58,655	8.3
400,000 to 500,000	101	1.6	45,129	6.8	127	2.0	56,645	8.0
500,000 to 600,000	67	1.1	36,928	5.5	80	1.3	43,979	6.2
600,000 to 700,000	32	.5	21,053	3.2	45	.7	29,441	4.1
700,000 to 800,000	36	.6	26,852	4.0	19	.3	14,483	2.0
800,000 to 900,000	25	.4	21,300	3.2	30	.5	25,479	3.6
900,000 to 1,000,000	20	.3	19,056	2.9	18	.3	17,063	2.4
1,000,000 and over	55	.9	80,409	12.0	66	1.0	100,481	14.1
Total	6,315	100.0	667,601	100.0	6,296	100.0	710,934	100.0

[1] Includes a few companies operating more than 1 plant but not submitting separate returns for individual plants.

Table 9.—Sand and gravel sold or used in the United States, by classes of operation and method of transportation

	1967		1968	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Commercial:				
Truck	573,765	63	616,956	67
Rail	57,799	7	58,405	6
Waterway	32,979	4	34,294	4
Unspecified	3,058	(1)	1,279	(1)
Total commercial	667,601	74	710,934	77
Government-and-contractor: Truck [2]	[r] 239,444	26	206,805	23
Grand total	[r] 907,045	100	917,739	100

[r] Revised.
[1] Less than 0.5 percent.
[2] Entire output of Government-and-contractor operations assumed to be moved by truck.

Table 10.—Ground sand sold or used by producers in the United States,[1] by use

(Thousand short tons and thousand dollars)

Use	1967		1968	
	Quantity	Value	Quantity	Value
Abrasives	302	$1,844	179	$1,733
Chemicals	39	377	96	535
Enamel	12	132	13	143
Filler	120	1,061	117	988
Foundry uses	140	1,115	183	1,141
Glass	334	1,337	207	1,357
Pottery, porcelain, tile	256	2,580	258	2,708
Unspecified	287	2,537	295	3,128
Total	1,490	10,983	1,348	11,733

[1] Arkansas, California, Florida, Georgia, Idaho, Illinois, Indiana, Kansas, Kentucky (1968 only) Louisiana, Maryland (1967 only), Michigan, Minnesota, Missouri, New Jersey, New York, Ohio, Oklahoma, Pennsylvania, South Carolina, Tennessee (1968 only), Texas, Utah (1968 only), Virginia, West Virginia, and Wisconsin (1968 only).

Table 11.—U.S. imports for consumption of sand and gravel, by class

(Thousand short tons and thousand dollars)

Year	Glass sand [1]		Sand, n.s.p.f., crude or manufactured and gravel		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1966	18	$95	631	$811	649	$906
1967	44	159	588	753	632	912
1968	25	144	729	984	754	1,128

[1] Classification reads: "Sands containing 95 percent or more silica and not more than 0.6 percent oxide of iron and suitable for manufacturing glass."

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/76

Silicon

By John W. Thatcher [1]

Production of silicon metal increased, as two large electric smelting furnaces installed late in 1967 reached full design capacity. Production of specialized silicon alloys also increased and several new additives were marketed which were "tailor-made" for specific jobs in steelmaking. Sales of silicon transistors increased and silicon demand for this use was more than double that for germanium.

DOMESTIC PRODUCTION

On a gross weight basis, net production of ferrosilicon was essentially unchanged from 1967 while production of silvery pig iron decreased 7 percent. The ratio of production of ferrosilicon to silvery pig iron has gradually increased from about 1:1 in 1961 to 3:1 in 1968, reflecting both the increasing demand by steelmakers for specialized raw materials and the growth of electric furnace smelting technology.

Looking at the individual ferrosilicon grades, the production of nominal 50-percent ferrosilicon in 1968 changed little from the level maintained since 1964. In the period 1961–64, annual production of this grade had doubled. The production of 65-percent ferrosilicon, used mainly for producing electrical sheet steel, decreased 31 percent in 1968 from that for 1967, while the production of 75-percent ferrosilicon, which has shown steady growth since 1962, increased 13 percent over that for 1967. The production of 85-percent ferrosilicon dropped somewhat in 1968, but was still close to the trend line which shows a fivefold growth since 1961. The production of 93-percent ferrosilicon continued to decline in 1968 but not as sharply as in the period 1961–65. Silicon metal is replacing this alloy in many applications. The production of ferrosilicon briquets, which are used mainly in cupola operations, had increased yearly until 1964, but since that time has shown no distinct trend, fluctuating in the range 61,000 to 76,000 tons per year. The growth in production of miscellaneous silicon alloys has been particularly noteworthy, increasing from

Table 1.—Production, shipments, and stocks of silvery pig iron, ferrosilicon, and silicon metal in 1968[1]

(Short tons, gross weight)

Alloy Type	Silicon content (percent)	Producers' stocks as of Dec. 31, 1967	Production	Shipments	Producers' stocks as of Dec. 31, 1968
Silvery pig iron	5–20	[r] 50,739	203,867	237,470	19,265
Ferrosilicon	21–55	[r] 50,988	352,883	370,938	31,944
Do	56–70	[r] 5,406	16,804	17,994	3,992
Do	71–80	17,127	95,249	98,495	12,783
Do	81–89	4,283	33,076	34,530	3,157
Do	90–95	391	724	616	121
Silicon metal	96–99	5,856	96,261	97,287	4,853
Ferrosilicon briquets	40–50	4,610	64,900	66,471	2,111
Miscellaneous silicon alloys	---------	4,795	31,039	30,622	5,411

[r] Revised.
[1] Excludes ferrosilicon used to make other silicon alloys.

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Producers of silicon alloys and/or silicon metal in the United States in 1968

Producers	Plant location	Product
Air Reduction Co., Inc., Airco Alloys and Carbide Division.	Calvert City, Ky	FeSi.
Do	Charleston, S.C	Do.
Do	Niagara Falls, N.Y	FeSi, silvery iron.
Calumet & Hecla, Inc	Selma, Ala	FeSi.
Chromium Mining and Smelting Corp	Woodstock, Tenn	Do.
Foote Mineral Co	Graham, W. Va	FeSi, Si.
Do	Keokuk, Iowa	FeSi, silvery iron.
Do	Vancoram, Ohio	FeSi.
Do	Wenatchee, Wash	FeSi, Si.
The Hanna Furnace Corp	Buffalo, N. Y	Silvery iron.
Hanna Nickel Smelting Co	Riddle, Oreg	FeSi.
Imperial Metals & Abrasives	Centralia, Wash	FeSi, silvery iron, Si.
Interlake Steel Corp	Beverly, Ohio	Do.
Jackson Iron & Steel Co	Jackson, Ohio	Silvery iron.
Kawecki Chemical and Berylium Co	Springfield, Oreg	FeSi.
Ohio Ferro-Alloys Corp	Brilliant, Ohio	FeSi, Si.
Do	Philo, Ohio	Do.
Do	Powhatan Point, Ohio	Do.
Do	Tacoma, Wash	Do.
Reynolds Metal Co	Sheffield, Ala	Si.
Tennessee Alloys Corp	Bridgeport, Ala	FeSi.
Tennessee Metallurgical Co	Kimball, Tenn	Si.
Union Carbide Corp., Mining & Metals Division	Alloy, W. Va	FeSi, Si.
Do	Ashtabula, Ohio	FeSi.
Do	Marietta, Ohio	Do.
Do	Portland, Oreg	Do.
Do	Rockwood, Tenn	Do.
Do	Sheffield, Ala	Do.
Woodward Corp	Woodward, Ala	Do.

6,000 tons in 1961 to 31,000 tons in 1968. In addition to iron and silicon, these alloys contain one or two of the following elements: Aluminum, barium, boron, calcium, cerium, magnesium, manganese, titanium, and/or zirconium. Changing steelmaking technology and the demand for high-performance iron and steel products have stimulated the production of these specialized ferrosilicon additives.

CONSUMPTION AND USES

The consumption of silvery iron in 1968 decreased from that of the previous year while the consumption of ferrosilicon and silicon metal remained essentially unchanged. A small but possibly significant increase in the use of silicon metal in carbon steel castings was noted. A trend in this direction, coupled with the anticipated growth of continuous cast carbon steels, could result in a significant new use for silicon metal in the future.

Several new silicon alloys were developed for steelmaking and foundry operations during the year. A new 50-percent grade of ferrosilicon, called "Hard-Cast" and claimed to generate almost 60 percent less fines on handling, was introduced by Union Carbide Corp. Two new deoxidizers were also marketed by the company: "Calsibar," a barium-calcium silicon alloy that is less reactive when added to steel, allowing improved calcium efficiency and more consistent inclusion control; and "Hypercal," a patented calcium-barium-silicon-aluminum alloy that modifies aluminum-formed inclusions thus improves ductility, toughness, fatigue resistance, and surface condition of wrought and cast steels. A new cerium-bearing magnesium-ferrosilicon was also introduced that is claimed to give better ductile-iron structures at a lower cost.

Table 3.—Consumption by major end uses, and stocks, of silicon alloys and metal in the United States in 1968

(Short tons)

Alloy and metal	Silicon content (percent)	High speed and tool	Stainless	Alloy (excluding stainless)	Carbon	Cast irons
Silvery pig iron	5–20	---------	W	5,851	15,335	133,417
Ferrosilicon (includes briquets)	21–55	1,481	16,280	34,300	109,086	169,597
Do	56–80	344	6,313	33,125	32,444	18,413
Do	81–95	11	176	1,385	W	7,317
Silicon metal	96–99	W	42	1,602	W	W
Miscellaneous silicon alloys [1]	-------	46	284	4,731	13,446	56,039
Total	-------	1,882	23,095	80,994	170,311	384,783
	Nonferrous alloys	Electrical materials	Chemical and ceramic uses	Miscellaneous and unspecified	Total	Stocks Dec. 31 1968
Silvery pig iron	W	---------	3,215	713	158,531	17,364
Ferrosilicon (includes briquets)	384	183	1,357	17,735	350,403	29,643
Do	373	---------	915	699	92,626	8,631
Do	1,841	W	35	1,211	11,976	1,756
Silicon metal	39,094	335	20,498	2,036	63,607	5,361
Miscellaneous silicon alloys [1]	960	---------	W	6,244	81,750	4,597
Total	42,652	518	26,020	28,638	758,893	67,352

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."

[1] Includes calcium-silicon, calcium-manganese-silicon, silicon-manganese-zirconium, Ferrocarbo (including briquets), Alsifer, and other miscellaneous silicon alloys.

PRICES

The price of the 50-percent grade of ferrosilicon, which had remained at 13.1 cents per pound of contained silicon since the second quarter of 1966, was raised, effective April 1, to 13.5 cents f.o.b. shipping point, freight equalized to nearest main producer, carload lots, lump, bulk. Announcements of a further increase in the price of this grade to 13.8 cents per pound of contained silicon, same basis, effective January 2, 1969, were made by two major producers at yearend. Price increases, effective January 2, 1969, were also announced for ferroaluminum-silicon, silicon briquets, silicon-manganese-zirconium alloys, calcium-silicon, and zirconium-silicon.

The price of metallurgical grade silicon metal, which had remained since 1966 at 18.05 cents per pound of contained silicon, f.o.b. producer's plant, was raised 0.5 cent per pound of silicon across the board for all grades and sizes effective October 1.

In the third quarter, Dow Corning Corp., Midland, Mich., announced a 10-percent price increase for high-purity silicon metal to be effective September 17, and a 5- to 7-percent price increase on silicone fluids and emulsions to be effective September 23.

FOREIGN TRADE

Net trade in ferrosilicon, unfavorable to the United States in 1966 and 1967, was reversed in 1968 despite a surge of imports late in the year. Total value of ferrosilicon exported exceeded total value of that imported by about $1.3 million. Canada and West Germany each took 36 percent of the exports; the United Kingdom took 17 percent; Sweden, Mexico, Turkey, and Australia combined took 9 percent; and 14 other countries took the remainder. There were no reported U.S. exports of ferrosilicon to Japan.

Table 4.—U.S. exports of ferrosilicon

Year	Short tons	Value (thousands)
1966	5,812	$2,004
1967	11,774	3,228
1968	18,372	4,481

Imports of the 60- to 80-percent grade of ferrosilicon, which had reached a record level of 15,585 short tons in 1967, dropped 48 percent in 1968 resulting in a 28-percent decrease in value of total ferrosilicon imports.

Imports for consumption of high-purity silicon, which were 42,357 pounds in 1967, increased slightly to a new record high of 42,390 pounds in 1968. Total value decreased 19 percent from that for 1967, and value per unit of weight dropped from $50.20 per pound in 1967 to $40.49 per pound in 1968. Percentage contributions on a weight basis were West Germany, 88.5; Japan, 7; Switzerland, 2.3; Belgium-Luxembourg, 2.1; and the remainder from Denmark, United Kingdom, and Italy, in that order.

Table 5.—U.S. imports for consumption of ferrosilicon and silicon metal, by grades and countries

	1966			1967			1968		
	Short tons		Value (thousands)	Short tons		Value (thousands)	Short tons		Value (thousands)
	Gross weight	Silicon content		Gross weight	Silicon content		Gross weight	Silicon content	
FERROSILICON									
8 percent and less than 60 percent silicon:									
Canada	14,121	2,469	$811	10,673	1,846	$621	12,419	2,608	$729
France	483	259	149	215	116	67	354	171	97
Germany, West	949	432	258	502	242	144	281	130	74
Japan	2,321	1,089	631	2,621	1,265	698	3,459	1,705	884
Norway	-----	-----	-----	552	247	180	1	(1)	(1)
Total	17,874	4,249	1,849	14,563	3,716	1,710	16,514	4,614	1,784
60 percent and not more than 80 percent silicon:									
France	3,867	2,573	1,011	5,493	3,922	1,093	1,849	1,127	550
Germany, West	2,416	1,480	797	887	545	306	462	277	187
Greece	-----	-----	-----	-----	-----	-----	1,103	842	60
India	-----	-----	-----	110	87	14	-----	-----	-----
Norway	5,013	3,852	743	6,601	5,018	941	1,037	794	141
Portugal	-----	-----	-----	27	21	4	-----	-----	-----
Rhodesia, Southern	-----	-----	-----	-----	-----	-----	1,459	1,117	186
South Africa, n.e.c	-----	-----	-----	-----	-----	-----	21	16	3
South Africa, Republic of	901	697	133	549	420	84	1,292	1,006	183
Sweden	-----	-----	-----	1,918	1,450	263	-----	-----	-----
Yugoslavia	-----	-----	-----	-----	-----	-----	817	531	90
Total	12,197	8,602	2,684	15,585	11,463	2,705	8,040	5,710	1,350
Over 80 percent but not over 90 percent silicon:									
Canada	55	46	15	-----	-----	-----	-----	-----	-----
Italy	224	192	53	185	158	41	178	153	38
Norway	55	44	9	-----	-----	-----	-----	-----	-----
South Africa, Republic of	-----	-----	-----	-----	-----	-----	158	135	35
Total	334	282	77	185	158	41	336	288	73
Grand total	30,405	13,133	4,610	30,333	15,337	4,456	24,890	10,612	3,207
SILICON METAL									
Canada	1,439	1,337	128	-----	-----	-----	-----	-----	-----
Italy	(1)	(1)	1	39	38	15	42	42	15
Japan	-----	-----	-----	5	5	1	-----	-----	-----
Norway	86	79	25	-----	-----	-----	-----	-----	-----
Sweden	55	54	15	-----	-----	-----	-----	-----	-----
Yugoslavia	-----	-----	-----	-----	-----	-----	6	6	2
Total	1,580	1,470	169	44	43	16	48	48	17

[1] Less than ½ unit.

WORLD REVIEW

Canada.—Industrial Minerals of Canada, Ltd., Toronto, a subsidiary of Falconbridge Nickel Mines Ltd., announced in July the purchase of the Killarney silica property in the Georgian Bay area from Union Carbide Canada Ltd. The mine and crushing plant at Killarney will be operated in conjunction with a new open-pit, high-grade silica mine which Industrial Minerals will develop on adjacent Badgeley Island. The crushed silica will be shipped directly to ferrosilicon and silicon metal producers, and to a new $1.5 million grinding plant which will be built by Industrial Minerals at Midland, Ontario, 120 miles from Killarney. The entire $3 million development program is expected to be completed in early 1970.

Silica production in 1968 was 2.6 million tons valued at $6.5 million; the volume of production was slightly higher than in 1967 and the value was 17 percent higher. Most silica production was in the form of low-grade lump silica and low-grade sand utilized as metallurgical flux. The search for high-quality silica deposits continued in 1968.

Japan.—The shortage of ferrosilicon supply was eased somewhat in 1968 as several calcium carbide chemical plants, unable to compete with petrochemical plants for a shrinking carbide market, began converting furnaces to the production of ferrosilicon. Reports from London indicate Nippon Carbide Industry will produce 6,000 tons of ferrosilicon per year in a 15,000-kilovolt-ampere furnace at its Uozu calcium carbide plant. Reports also indicate that the calcium carbide producer, Ube Kosan, will install a second 15,000-kilovolt-ampere furnace which will triple its production of silicon alloys at startup in mid-1969.

Norway.—Norway solidified its position as the world's third leading ferrosilicon producer by increasing production in 1968 to 385,000 short tons (45 percent Si). This 68,000-ton increase over 1967 production was due principally to the installation of a new furnace at the Salten Verk smelter of Elektrokemish A/S in northern Norway. In addition to the ferrosilicon production, there were 6,600 tons of ferrosilicon briquets; 5,960 tons of silicochrome; 150,000 tons of silicomanganese; 46,500 tons of silicon carbide; and 15,500 tons of silicon metal produced in 1968.

A/S Ila og Lilleby Smelteverker installed a third furnace at its Holla Smelteverk, Sagoren, Norway, which brings the capacity of that plant to 50,000 tons of 45-percent ferrosilicon per year and establishes the company as the third largest producer of ferrosilicon in Norway.

South Africa, Republic of.—A new company, Heavy Media Materials (Pty.) Ltd. (HYMAT), was formed to produce atomized, spheroidized, and milled ferrosilicon, all of which will be used in the heavy media separation process in mineral extraction. The major partner in the enterprise is African Metals Corporation, Ltd. (AMCOR), with 52 percent of the shareholdings. The South African Iron and Steel Industrial Corporation (ISCOR) has a 22-percent interest and Fabwerke Hoechst A.G. of West Germany, a 26-percent interest. AMCOR will build and operate a plant at Kookfontein which will have an initial capacity of 3,500 short tons per year of atomized, 15-percent ferrosilicon. In addition to supplying the growing South African demand, it is expected that HYMAT will be able to export this material, which is of particular use in iron ore and diamond ore beneficiation. Sales will be handled by Hoechst South Africa (Pty.) Ltd.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/54

Silver

By J. Patrick Ryan [1]

Domestic mine production of silver, although slightly more than in 1967, was depressed for the second consecutive year by the copper strike which continued through the first quarter. Strong speculative and investment demand with wide fluctuations of price, which reached a record high in June, were salient features of the silver market in 1968. The U.S. Treasury continued the ban on private melting of coins, terminated the redemption of silver certificates in silver, and continued weekly silver sales and the minting of 40-percent silver half dollars.

U.S. consumption of silver for industrial uses and coinage dropped appreciably compared with that in 1967. The heavy outflow for commercial use, coinage, and strategic reserves continued to deplete Treasury bullion stocks. Silver stocks by speculators, investors, and industrial fabricators increased substantially in spite of record high price levels. Trading activity on the New York Commodity Exchange again reached record levels as total volume of transactions increased to more than three times the 1967 volume. U.S. foreign trade in silver continued a net export pattern for the third consecutive year. Both exports and imports were substantially greater than in 1967.

World silver production increased appreciably to the highest level since 1940. World industrial consumption of silver was down slightly, but the quantity of silver used in coinage dropped appreciably.

Table 1.—Salient silver statistics

	1964	1965	1966	1967	1968
United States:					
Mine production thousand troy ounces	36,334	39,806	43,669	[r] 32,345	32,729
Value thousands	$46,980	$51,469	$56,464	[r] $50,135	$70,191
Ore (dry and siliceous) produced:					
Gold ore thousand short tons	2,631	3,113	2,580	2,315	2,003
Gold-silver ore do	224	205	248	157	199
Silver ore do	644	902	1,069	904	701
Percentage derived from—					
Dry and siliceous ores	32	35	33	39	39
Base-metal ores	68	65	67	61	61
Refinery production [1] thousand troy ounces	[2] 37,000	[2] 39,000	[2] 48,358	30,268	42,052
Exports [3] do	109,395	39,665	85,538	70,769	125,761
Imports, general [3] do	51,674	54,709	63,032	55,520	70,709
Stocks Dec. 31:					
Treasury [4] million troy ounces	1,218	804	594	351	• 240
Industry [5] do	---------	---------	57,244	83,353	166,356
Consumption: Industry and the arts thousand troy ounces	123,000	137,000	183,696	171,031	145,293
Coinage do	203,000	320,321	53,852	43,851	36,833
Price [6] per troy ounce	$1.293 +	$1.293 +	$1.293 +	$1.550 +	$2.144 +
World:					
Production thousand troy ounces	248,545	257,415	266,731	259,081	272,507
Consumption [7]: Industry and the arts thousand troy ounces	[r] 299,200	[r] 336,600	[r] 355,100	[r] 348,600	347,300
Coinage [8] do	[r] 267,100	[r] 381,100	[r] 130,700	[r] 89,200	59,500

• Estimate. [r] Revised.
[1] From domestic ores.
[2] U.S. Bureau of the mint.
[3] Excludes coinage.
[4] Excludes silver in silver dollars.
[5] Includes silver in COMEX warehouses.
[6] Average New York price.
[7] Free world only. Source: Handy & Harman, 1964–65; U.S. Bureau of Mines, 1966–68.
[8] Free world only. Source: Handy & Harman.

---

[1] Physical scientist, Division of Mineral Studies.

Legislation and Government Programs.—As provided in Public Law 90–29 enacted on June 24, 1967, the redemption of silver certificates in silver was terminated on June 24, 1968. Also, implementing directives to the Secretary of the Treasury in the law, a reserve supply of 165 million ounces was transferred to the strategic stockpile. As supplies declined, the Treasury authorized the General Services Administration to halt sales of 999 fine silver on April 28 and to begin on May 3 the sale of silver of less than commercial grade, largely coin silver 900 fine.

The Joint Commission on the Coinage established in 1967 recommended that weekly sales of Treasury silver and the ban on private melting or exporting of silver coins be continued. The Commission also recommended that the Treasury make the ban on private melting permanent, and that the 2.9 million rare silver dollars in the Treasury be sold on a bid-sale basis.

The Commission also voted to request legislation authorizing the minting of a non-silver-clad half-dollar, with the Mint continuing to mint the 40-percent-silver half dollar at the current rate (100 million pieces) requiring 15 million ounces annually, until such new authority is granted.

Nine contracts totaling $548,480 were executed for silver exploration during the year under the financial assistance program administered by the Office of Minerals Exploration, U.S. Geological Survey. The Government share of the total cost was $431,360.

The following exploration contracts for silver or silver-gold were active or in force at yearend:

Operator	Location	Total cost
Betty O'Neal Silver, Inc.	Lander, Nev	$90,240
Cardiff Industries, Inc.	Salt Lake, Utah.	10,500
Donald C. Gilbert	Santa Cruz, Ariz.	14,000
Don H. Clair, et al	Esmeralda, Nev.	44,200
Busty Belle Mines, Inc.	Fourth District, Alaska.	34,200
Silver Cloud, Inc	Humboldt, Nev.	32,000
Big Treasure Mining & Development Co.	Pinal, Ariz	112,000
Congdon & Carey	Custer, Colo	54,660
Great Eastern Mines	San Juan, Colo	81,200
A & B Silver Mines	Lincoln, Nev	72,000
A. A. Peugnet	Yavapi, Ariz	23,800
Sentinel Peek Mines	Inyo, Calif	36,000
McFarland & Hullinger.	Gunnison, Colo.	88,580
Triaqua Mining Co	Park, Colo	36,800
Geomineral Corp	San Bernardino, Calif.	20,000
Vitro Minerals Corp	San Juan, Colo	145,300
American Mining Co	Granite, Mont	38,200
Basic Resources Corp	Pershing, Nev	30,800
Bristol Silver Mines	Lincoln, Nev	129,000
Total		1,093,480

The Bureau of Mines distributed a 16-millimeter sound and color film showing mining, metallurgy, and manufacturing of silver. The film was produced in 1968 with the cooperation of American Smelting & Refining Co., The Anaconda Company, and Hecla Mining Co.

DOMESTIC PRODUCTION

Mine production of recoverable silver increased slightly in 1968 but was substantially below normal. Output of silver-lead-zinc and silver-bearing copper ores continued to be curtailed by the copper strike which reduced silver output about 40 percent during the first quarter.

Idaho's silver production declined 6 percent owing largely to the shutdown of the Lucky Friday, the Nation's third largest silver producer, during the first 5½ months. Output of silver in Arizona, Montana, and Utah increased appreciably reflecting settlement of the 9-month strike and return to normal productive operations at copper mines yielding byproduct silver. These four States contributed 86 percent of the total domestic output.

As in 1967 about 60 percent of the total silver production came from ores mined chiefly for copper, lead, and zinc, the remaining 40 percent was recovered from ores in which silver was the principal metal. Of the 25 leading silver-producing mines, which contributed 82 percent of the total domestic output, only four in Idaho depended chiefly on the value of the silver in the ore. Seven of the mines produced over 1 million ounces each, supplying 65 percent of the total output. Domestic mines furnished about 22 percent of the total silver used in the Nation's arts and industries.

Hecla Mining Co. reported a total silver output of 4.97 million ounces compared with 6.15 million ounces in 1967, from five operating mines including a one-third interest in the Sunshine unit area and a 30-percent interest in Star-Morning unit. The Lucky Friday mine in the Coeur d'Alene district, Idaho, treated 95,923 tons of ore assaying 15.7 ounces of silver, 10 percent lead, and 0.9 percent zinc yielding 1.47 million ounces of silver. The 34-percent reduction in tonnage was due to a strike extending from October 15, 1967, to June 15, 1968. Curtailed development work resulted in a decrease in ore reserves from 677,000 tons at the beginning of the year to 626,000 tons at yearend. At the Mayflower mine in the Park City district, Utah, Hecla mined and treated 122,357 tons of ore assaying 0.53 ounce of gold per ton, 4.8 ounces of silver per ton, 4.0 percent lead, 3.2 percent zinc, and 0.9 percent copper yielding 543,600 ounces of silver. Estimated ore reserves dropped 22,000 tons to 309,000 tons at yearend. The inflow of appreciable quantities of hot water on the lower levels, which necessitated grouting to seal, slowed development. At the Silver Summit mine the company milled 21,932 tons of ore assaying 17.0 ounces of silver and 0.5 percent copper. Estimated ore reserves at yearend were 29,000 tons, about 5,000 tons less than those a year earlier. A major effort was being directed toward consolidation of several properties adjoining the Silver Summit to justify comprehensive deep exploration and development of favorable ore horizons through extensions of present openings at the Silver Summit.

The Star-Morning mines produced 189,936 tons of ore assaying 2.2 ounces of silver, 4.9 percent lead and 8.8 percent zinc. Hecla's share of the ore reserves decreased from 335,000 tons at the beginning of the year to 288,000 tons at yearend. The company reported substantial progress on its shaft and deep level development below the 7,100 foot level. Exploration of the adjoining Independence property was scheduled to commence after completion of the new No. 4 shaft project.[2]

American Smelting and Refining Co. (ASARCO) operated the Galena mine during the last 8-months of the year following settlement of the strike and milled 92,660 tons of ore averaging 21.2 ounces of silver per ton and 0.8 percent copper. Development work comprised 3,366 feet of drifting, 477 feet of crosscutting, 921 feet of raising and 16,120 feet of diamond drilling. Silver-copper ore reserves at Galena are sufficient for 6 years production at the increased milling rate of 750 tons per day which should be achieved by mid-1969.[3]

ASARCO completed the new Rainbow shaft 4,178 feet deep on its Coeur Project west of Wallace near the Galena mine and began lateral development on the Rainbow vein on the 3,100 and 3,400-foot levels. By yearend the 3,100 level disclosed 475 feet of silver-copper ore averaging 25.7 ounces of silver per ton and 1.2 percent copper across a width of 4.5 feet. The 3,400 level crosscut had not reached the vein at yearend. In addition to shaft sinking, development included 734 feet of drifting, 2,967 feet of crosscutting and 2,249 feet of diamond drilling. Ore reserves at yearend were estimated to exceed 50,000 tons averaging 23 ounces of silver per ton and 0.8 percent copper.[4]

Sunshine Mining Co. reported that output of silver at the Sunshine Mine, the Nation's leading silver producer, increased 0.16 million ounces to 7.71 million ounces of which Sunshine's share was 4.47 million ounces. Ore reserves increased 0.24 million tons to 1.08 million tons averaging about 42 ounces per ton at yearend, of which the company's share was 0.61 million tons. The company extended the No. 10 shaft to the 5,600 and 5,200 levels.[5]

Reports by smelters and refiners indicate that about 57 million ounces of silver was recovered from old scrap materials and returned to industrial use.

---

[2] Hecla Mining Co. 1968 Annual Report, pp. 8–10, 13.

[3] Day Mines Inc., Annual Report 1968, pp. 4–5.

[4] Work cited in footnote 3.

[5] Sunshine Mining Co. 1968 Annual Report, pp. 1, 10.

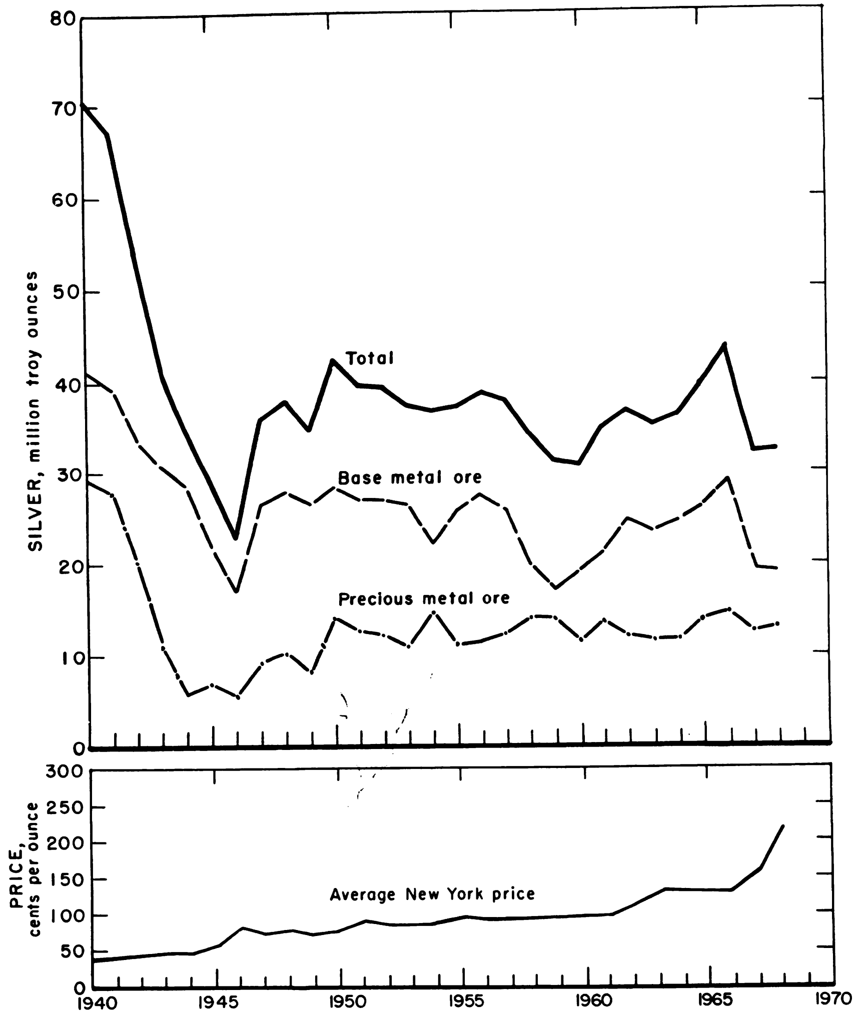

Figure 1.—Silver production in the United States and price per ounce.

CONSUMPTION AND USES

Data compiled by the Bureau of Mines indicate a moderate decline in industrial consumption of silver compared with 1967 levels. Total consumption dropped about 15 percent with declines recorded in all major use categories, except dental and medical. The quantity of silver used in photographic and electrical industries, the two largest consumers, was substantially less than in 1967. Photographic materials accounted for about 29 percent of the total industrial consumption of silver in 1968; electrical and electronic products, 22 percent; sterling ware, 20 percent; electroplated ware and brazing alloys, 10 percent each; and the remaining 9 percent was used in jewelry, dental and medical materials, catalysts, bearings, and miscellaneous products. Continued efficiencies in the use of silver in film emulsions and increased recovery of silver from process and product wastes was an important contributing factor in reducing the quantity of silver used in photographic materials. Several million ounces of silver were reclaimed from old film and from processing of emulsions stripped from film. The trend toward the use of bimetal composites, where technically and economically feasible to replace silver alloys, continued to reduce the quantity of silver required for electrical contacts. Solid state switching with controlled silicon rectifiers or power transistors began to replace some silver contacts. The sharp drop in the quantity of silver used in batteries largely reflects curtailed purchases of new silver and increased recovery and reuse of silver from battery and other scrap by the Navy Department.

Specially designed spark plugs with platinum electrodes and silver core ceramic insulators used in engine-compressors at Sun Oil Co.'s Marcus Hook, Pa., refinery provided six times longer life than previously used nickel electrode plugs. The silver core in direct contact with the electrode prevents overheating by transferring heat rapidly away from the tip.

Battelle Memorial Institute began a research study to find new ways to conserve silver in electrical contact materials especially in medium-to-high current applications. Batelle research will focus on pure silver, silver-cadmium, and silver-tungsten and will relate microstructural and compositional variations in materials to electrical contact performance, thus enabling consumers to design for optimum utilization of materials for particular needs.

A silver-palladium wiring paste laid onto ceramic substrates for microelectronic modules was reported by the Components Division, International Business Machines Corp., to effect a sharp reduction in cost, in addition to providing superior soldering and electrical characteristics. The paste contains four parts silver to one of palladium and is applied to substrates by silk screen to leave wires 0.004 inch wide. The paste is dried, fired, and tinned before resistors and semiconductors are added.

Yardney Electrical Corp. designed and built a "Silvered" silver-zinc propulsion battery and electronic scanner system for the new deep submergence rescue vehicles (DSRV) of the Navy Ship Systems Command. The new batteries will be tested to operate at a pressure of 9,000 pounds per square inch and are capable of supplying power to propel a submersible at depths up to 18,000 feet. The Yardney DSRV propulsion battery consists of two complete sets of 74-cell, 58-kilowatt-hour Silvercells housed in fiberglass battery boxes.

New plating techniques enabled United Aircraft Products to cover stainless steel hoops, up to 21 feet in diameter, with well-adhered, ductile silver. The hoops were installed in nuclear powerplants.

Consumption of silver in domestic coinage declined for the third consecutive year. About 36.8 million ounces were used in minting 40-percent-silver half dollars. The rate of minting silver half dollars was reduced to 100 million pieces per year requiring 15 million ounces of silver.

STOCKS

Outflow of silver from the Treasury bullion stock totaled about 381.4 million ounces comprising transfers to the Strategic Stockpile of 165.0 million ounces; G.S.A. sales, 105.2 million; redemptions of silver certificates, 74.2 million; minting 40-percent-silver half dollars, 36.8 million; and miscellaneous sales and disposals, 200,000 ounces.

Total yearend stocks were estimated at 240 million ounces comprising 70.9 million ounces of bullion and 169.1 million ounces in the form of unmelted coins. Most of the 179.4 million ounces withdrawn for commercial use went into industry stocks for consumption or was exported. Stocks of silver held by refiners, dealers, and fabricators totaled 77.2 million ounces at yearend, 25.2 million ounces more than those a year earlier. An additional 89.2 million ounces was held in Commodity Exchange warehouses at yearend compared with 31.2 million ounces at the end of 1967.

PRICES

The New York price of silver quoted daily by Handy & Harman fluctuated widely in 1968 reflecting monetary uncertainties and speculation concerning future supply and Government policy with respect to disposal of Treasury silver stocks. The daily price at New York in cents per ounce ranged between a low of 181.00 in mid-February to a record high of 256.50 in mid-June generally declining thereafter with frequent changes to 190.00 at yearend, averaging 214.46 for the year. Specific factors affecting speculation and price included uncertainty with regard to continuation of weekly GSA sales, redemption of silver certificates, commitments to deliver silver to the Strategic stockpile; and hedging activities following termination of gold sales on the London market.

General Services Administration sold at weekly auction silver of various fineness at several locations. Prices for 996–998 fine bullion at West Point ranged from a low of 167.00 cents per fine ounce in mid-February to a high of 243.05 cents per fine ounce in mid-May. Of a total of 105.2 million ounces sold, 56.6 million was 897–900 fine; 38.7 million was 996–998 fine; 9.2 million was 999 fine; and 700,000 was 830–896 fine.

The volume of trading on the New York Commodity Exchange (COMEX) established a new record of nearly 4.9 million ounces compared with 1.5 million ounces in 1967. COMEX prices ranged from a high of 288.80 cents on May 20, for September 1969 delivery, to a low of 183.50 cents on October 22 for October 1968 delivery. At yearend open contracts for 561.5 million ounces were outstanding, compared with 257.4 million ounces at the end of 1967.

In the London market prices for spot delivery, in terms of U.S. funds, ranged from an alltime record high of 257.6 cents on June 12 to a low of 184.2 cents on October 17. The average price for the year was 219.44 pence equivalent to approximately 218.93 cents at the average rate of exchange for Sterling. The London forward quotations for 3 months', 6 months', and 12 months' delivery, in cents per ounce, averaged 223.47, 228.41, and 238.91 respectively.

FOREIGN TRADE

Exports of silver increased 78 percent in 1968 to 125.8 million ounces, the highest level of exports in recent years. About 45 percent of the silver exported went to the United Kingdom, 13 percent went to Switzerland and 10 percent to Canada. Substantial quantities of silver also were shipped to Belgium-Luxembourg, France, Mexico, and the Netherlands.

Imports of silver totaled 70.7 million ounces, an increase of about 27 percent over 1967 imports. Canada shipped 39.6 million ounces, about 56 percent of the total silver imported; Peru shipped 5.8 million ounces or about 8 percent of the total; Mexico shipped 10.3 million ounces or 15 percent; and 16 other countries shipped virtually all of the remaining 15.1 million ounces received.

Net exports were 55.0 million ounces compared with net exports of 15.3 million ounces in 1967.

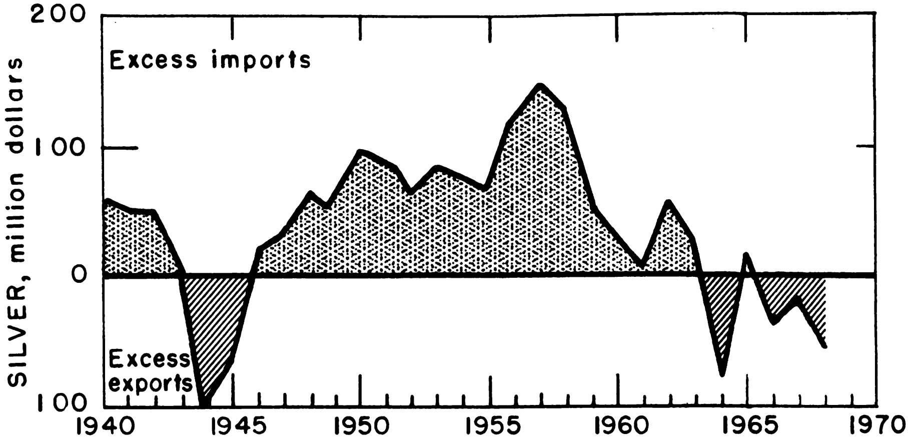

Figure 2.—Net exports or imports of silver.

WORLD REVIEW

World silver production was estimated at 272.7 million ounces approximately 13.6 million ounces more than in 1967. Production gains were recorded in most silver-producing countries including Canada, Mexico, the United States, and Australia.

Western Hemisphere countries contributed about 62 percent of the total world output.

Consumption of silver in the arts and industries, and in coinage of non-Communist-dominated countries totaled about 406.8 million ounces, 8 percent less than in 1967. Industrial consumption of 347.3 million ounces was only slightly less than in 1967 but coinage use declined 33 percent to 59.5 million ounces. Free-world silver consumption exceeded new production by approximately 134.1 million ounces. The production deficit continued to be balanced chiefly by withdrawals from U.S. Treasury stocks, foreign Government stocks, demonetized coin, and other secondary sources. Inventory accumulation and speculative holdings increased about 170 million ounces during the year. At yearend total worldwide speculative and investment stocks were approximately 370 million ounces. Also during 1968 some 60 million ounces came out of India and the Near East and some 40 million ounces came from demonetized coin mostly Australian and Canadian.

Australia.—Output of silver, recovered mainly as a byproduct of lead production, increased 9 percent to a record high of 21.6 million ounces.

Mount Isa Mines Ltd. treated 3.6 million tons of silver-lead-zinc and copper ores in the year ending June 30 recovering 7.3 million ounces of silver compared with 5.8 million ounces in 1967. The production gain was due largely to commissioning of a new shaft and ore treatment facilities permitting expansion of lead-zinc ore production. A total of 31,155 feet of surface exploratory drilling was completed. Ore widths were cut in four holes ranging over 3,600 feet of strike and penetrating to a maximum depth of 3,500 feet. Underground exploratory drilling totaling 113,212 feet resulted in some extensions to known orebodies. Ore reserves of silver-lead-zinc increased 2 million tons to 34.6 million tons averaging 5.2 ounces of silver per ton, 7.2 percent lead, and 5.6 percent zinc. Average daily treatment rate was 10,064 tons compared with 10,469 tons in 1967.[6]

Canada.—Mine production of silver increased 9.3 million ounces to 45.6 million ounces, the fifth consecutive annual gain and a new alltime record. The production gain was due chiefly to expanded metal output at the Kidd Creek mine of Texas Gulf Sulphur Co. near Timmins, Ontario. Silver was recovered at Kidd Creek as a coproduct of zinc, lead, and copper.

---

[6] Mount Isa Mines Ltd. Annual Report. 1968, pp. 17–19.

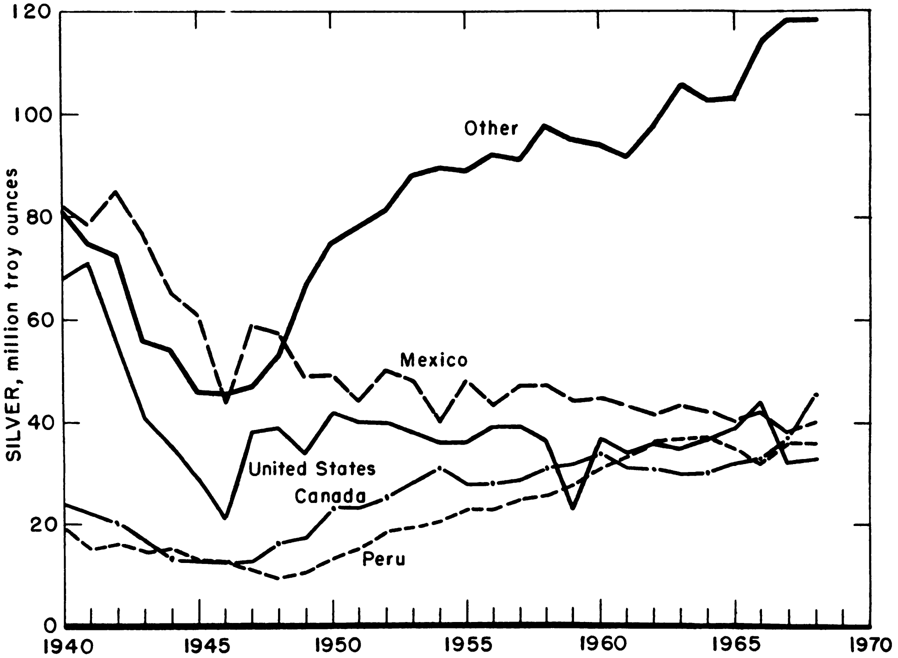

Figure 3.—World production of silver.

Canada became the leading silver-producing country in 1968, displacing Mexico. Of the total production, about 86 percent is recovered from ores mined essentially for base metals; virtually all of the remaining 14 percent came from silver-cobalt and gold ores.

Canada: Geographical distribution of silver production

(Troy ounces)

Province or Territory	1967	1968 [p]
Alberta	14	10
British Columbia	6,082,617	6,977,705
Manitoba and Saskatchewan	1,234,526	1,304,070
New Brunswick	3,017,416	3,459,000
Newfoundland	1,073,153	1,110,000
Northwestern Territories	1,980,228	3,855,967
Nova Scotia	89,238	246,136
Ontario	14,309,391	22,591,106
Quebec	4,659,232	4,015,827
Yukon Territory	3,869,374	2,061,534
Total	36,315,189	45,621,355

[p] Preliminary.
Source: Dominion Bureau of Statistics.

In the Yukon Territory (Y.T.,) a substantial decrease in silver output was attributed to curtailed operations by United Keno Hill Mines Ltd. Two new mines, Arctic Gold and Silver Mines Ltd., near Careross, Y.T., and Mount Nassen Mines Ltd., near Carmacks, Y.T., began production in the latter half of 1968. Anvil Mining Corp. Ltd. continued construction of its 5,500-ton-per-day mill to treat zinc-lead-silver ore from its Faro mine near Ross River, Y.T. Initial production is scheduled for late 1969.

In British Columbia gains in silver production were recorded by Western Mines Ltd., by Utica Mines Ltd. following the first full year's operation, and by Cominco Ltd., the Province's largest silver producer.

Five base metal mines operated by Hudson Bay Mining and Smelting Co., Ltd. near Flin Flon and Snow Lake continued to account for most of the silver produced in Manitoba.

Most of the silver in silver-cobalt ores and concentrates from the Cobalt and Gowganda areas of Ontario were treated at the Kam-Kotia refinery at Cobalt but some silver was recovered at the East Helena, Mont., refinery of ASARCO and the Noranda copper refinery in Montreal East.

Silver output in Quebec, recovered almost entirely from base metal and gold ores, declined moderately. Gaspe Copper Mines and Lake Dufault Mines Ltd. were the Province's largest silver producers; 11 other Quebec mines also produced significant quantities of silver.

Virtually all the silver output of the Northwest Territories came from the Echo Bay Mines Ltd. silver-copper property near Port Radium.

Consumption of silver in the arts and industries was 5.1 million ounces, about 300,000 ounces less than in 1967. About 4.4 million ounces of silver were used in minting 500-fine coins, 3.8 million ounces less than in 1967. These coins were minted instead of the previous 800-fine coins to conserve silver until the newly authorized pure nickel coins began to circulate in August. The Canadian Government prohibited the melting and exporting of silver coins. Exports of refined and unrefined silver to the United States increased about 16.2 million ounces to 39.6 million ounces. Total exports of silver are estimated at 44.0 million ounces. Imports totaled about 14.7 million ounces, about half of which was shipped from the United States for refining and eventual return.

Texas Gulf Sulphur Co.'s Kidd Creek mine, Canada's largest silver producer, mined and milled 3.6 million tons of zinc-copper-silver-lead ore and produced 13.4 million ounces of silver. The company reported that metal recoveries were improved at the concentrator and that several additional products, such as pyrite and tin, were recovered. The company also reported substantial progress on its comprehensive study regarding building its own smelter in Ontario to treat zinc, copper, and lead concentrates.[7]

Cominco Ltd. reported production of 6.9 million ounces of silver of which 62 percent came from company mines. In 1967 5.2 million ounces were produced, of which 67 percent came from company mines.

United Keno Hill Mines Ltd. reported that silver production dropped to 1.98 million ounces nearly 50 percent less than in 1967, the seventh successive annual decline. The company milled 60,800 tons of ore averaging 33.93 ounces of silver per ton, 6.53 percent lead, and 5.55 percent zinc compared with 106,200 tons averaging 37.69 ounces of silver per ton, 7.97 percent lead, and 5.89 percent zinc in 1967. Metal recoveries were as follows: Silver, 94.7 percent; lead, 94.2 percent; and zinc, 88.6 percent. Minable ore reserves were estimated at 100,230 tons averaging 39.2 ounces of silver per ton, 6.5 percent lead, and 5.5 percent zinc.[8]

Japan.—Mine production of silver dropped slightly in 1968 to 10.7 million ounces after four consecutive annual increases, but industrial consumption rose approximately 2.7 million ounces to 34.0 million ounces. No silver was used in coinage and none was recovered from coins in circulation. Imports of refined and unrefined silver totaled about 23.0 million ounces. Government stocks of silver were estimated at 25.0 million ounces.

Mexico.—Silver output in Mexico stimulated by higher metal prices, increased 2.1 million ounces to 40.0 million ounces but Mexico lost its customary rank as the leading silver producer to Canada. Industrial consumption was about 5.0 million ounces, about the same as in 1967. Silver used to complete the minting of the 25-peso silver coins commemorating the 1968 Olympic Games increased to 14.2 million ounces. Exports of silver totaled 35.2 million ounces of which 29.1 million ounces were shipped to Europe and 10.3 million ounces to the United States. Government stocks of bullion and coin at yearend were estimated at 10.5 million ounces about 16.5 million ounces less than at the end of 1967.

Asarco Mexicana, S.A., treated 2.0 million tons of silver-bearing ore from its own mines and from purchased ores and recovered 19.0 million ounces of silver compared with 1.9 million tons yielding 16.5 million ounces in 1967. The company reported continued progress on its mine and plant expansion program and that aggregate ore reserves at operating mines were well maintained.

Peru.—Output of silver in Peru, the third ranking silver producing country in 1968, increased slightly to 36.0 million ounces. Silver was recovered largely as a byproduct or coproduct of lead, zinc, and copper.

Cerro de Pasco Corp., the free world's

---

[7] Texas Gulf Sulphur Co. Annual Report. 1968, p. 8.

[8] United Keno Hill Mines Ltd. Annual Report. 1968, 12 pp.

second largest producer of silver, reported output from its mines and from purchased ore at 20.4 million ounces compared with 19.5 million ounces in 1967. About 47 percent of the corporation's silver output came from purchased ores.

United Kingdom.—Industrial consumption of silver was about 23.0 million ounces, slightly less than in 1967. The decline in consumption was attributed largely to the falloff in demand for domestic silverware due to the increase in the price of silver. Imports of silver totaled 125.9 million ounces, nearly double those in 1967. About 40.4 million ounces came from the United States, 41.1 million ounces from the Trucial States, mostly originating in India and Pakistan; 11.3 million ounces from Australia, 9.3 million ounces from Mexico and nearly all the remainder from 29 other countries. United Kingdom exports of silver dropped 2.3 million ounces to 29.4 million ounces. About 6.0 million ounces was shipped to Belgium; 5.5 million ounces to France; 4.6 million ounces to West Germany, 5.7 million ounces to Italy, 4.2 million ounces to Switzerland; and 1.3 million ounces to the United States. Nearly all of the remaining 2.1 million ounces went to Norway, Poland, Portugal, and 17 other countries.

About 1.4 million ounces of silver was recovered from demonetized United Kingdom silver coinage and sold on the London market.

TECHNOLOGY

Much research effort continued to be directed to developing photographic techniques which do not use silver and some progress was reported.

A new silverless electrophotographic process which is said to produce high-quality, continuous-tone photographic prints was developed by Charles D. Oughton and later acquired by UN Industries. The new process—called Contone—is reported to produce superior prints at lower cost in a shorter time than conventional silver processes. The process is electrostatic and uses a paper treated with special chemicals, including zinc oxide, and is made light sensitive by applying a uniform electrostatic charge. A toner makes images visible permanently. Commercial application of the Contone process could result in some reduction in silver used in the photographic industry.

Significant progress was made in improving techniques of cladding and electroplating silver to extend the use of bimetals-base metal-noble metal composites to conserve silver by limiting its use to applications where it is functionally required. Solid state switching with controlled silicon rectifiers or power transistors increased and eventually will replace many silver contacts.

The Bureau of Mines continued its research studies to develop improved techniques of measuring rock pressures and seismic effects related to controlling rock bursts. These studies were directed primarily toward alleviating environmental problems associated with deep silver-lead mines in the Coeur d'Alene Mining district, Idaho. Some progress was reported on improving methods of sampling and evaluating mineral deposits by applying computer techniques for data storage, retrieval and processing which will permit reliable appraisal of marginal silver-bearing deposits.

Handy & Harman reported the development of a process for manufacturing silver powders directly from the melt. The process which reached production levels in 1968, has resulted in better products and lower costs. The company also reported significant progress in improving processes for handling and recovery of precious metals from industrial scrap.

Table 2.—Mine production of recoverable silver in the United States, by months

(Thousand troy ounces)

Month	[r] 1967	1968
January	3,352	1,564
February	3,366	1,523
March	3,672	1,432
April	3,458	2,460
May	3,570	3,130
June	3,494	3,126
July	2,860	3,133
August	1,892	3,299
September	1,708	3,059
October	1,663	3,347
November	1,656	3,399
December	1,654	3,257
Total	32,345	32,729

[r] Revised.

Table 3.—Twenty-five leading silver-producing mines in the United States in 1968, in order of output

Rank	Mine	County and State	Operator	Source of silver
1	Sunshine	Shoshone, Idaho	Sunshine Mining Co	Silver ore.
2	Utah Copper	Salt Lake, Utah	Kennecott Copper Corp	Copper, gold-silver ores.
3	Galena	Shoshone, Idaho	American Smelting and Refining Co.	Silver ore.
4	Bunker Hill	do	The Bunker Hill Co	Lead-zinc, zinc ores, silver tailings.
5	Lucky Friday	do	Hecla Mining Co	Lead ore.
6	Crescent	do	The Bunker Hill Co	Silver ore.
7	Berkeley Pit	Silver Bow, Mont	The Anaconda Company	Copper ore.
8	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co.	Lead-zinc ore.
9	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
10	Pima	Pima, Ariz	Pima Mining Co	Copper ore.
11	Burgin	Utah, Utah	Kennecott Copper Corp	Lead-zinc ore.
12	Mineral Park	Mohave, Ariz	Duval Corp	Copper ore.
13	Copper Queen-Lavender Pit.	Cochise, Ariz	Phelps Dodge Corp	Do.
14	Mayflower	Wasatch, Utah	Hecla Mining Co	Copper-lead-zinc ore.
15	Morenci	Greenlee, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
16	Mission	Pima, Ariz	American Smelting and Refining Co.	Copper ore.
17	White Pine	Ontonagon, Mich	White Pine Copper Co	Do.
18	Darwin	Inyo, Calif	West Hill Exploration Co	Lead-zinc ore.
19	Silver Summit	Shoshone, Idaho	Hecla Mining Co	Silver ore.
20	Butte Hill Copper Mines.	Silver Bow, Mont	The Anaconda Company	Copper ore.
21	Star-Morning	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
22	New Cornelia	Pima, Ariz	Phelps Dodge Corp	Copper, gold-silver ores.
23	Magma	Pinal, Ariz	Magma Copper Co	Copper ore.
24	Copper Canyon	Lander, Nev	Duval Corp	Do.
25	Knob Hill	Ferry, Wash	Knob Hill Mines, Inc	Gold ore.

Table 4.—Production of silver in the United States, by type of mine, and by class of ore yielding silver, in terms of recoverable metal, 1968

State	Placer	Lode					
	Troy ounces of silver	Gold ore		Gold-silver ore		Silver ore	
		Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	1,329	100	2,441	--------	--------	--------	--------
Arizona	------	72	65	59,762	3,441	43,982	35,800
California	321	3,153	506	3,075	21,673	271	8,019
Colorado	220	351	551	2,355	5,993	70,425	158,143
Idaho	------	124	199	27	806	479,647	11,863,938
Michigan	------	--------	--------	--------	--------	--------	--------
Missouri	------	--------	--------	--------	--------	--------	--------
Montana	------	225	313	12,383	39,460	55,006	299,508
Nevada	34	815	153	--------	--------	27,093	28,554
New Mexico	35	--------	--------	3,086	48,401	414	2,486
New York	------	--------	--------	--------	--------	--------	--------
Oregon	------	15	2	--------	--------	2	42
South Dakota	752	1,921,653	136,916	--------	--------	--------	--------
Tennessee	------	--------	--------	--------	--------	--------	--------
Utah	------	--------	--------	118,117	14,018	23,819	54,692
Other States [5]	------	76,631	291,608	--------	--------	17	32
Total	2,691	2,003,139	432,754	198,805	133,792	700,676	12,451,214
Percent of total silver	(4)	--------	1	--------	(4)	--------	38

State	Lode—continued					
	Copper ore		Lead ore		Zinc ore	
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver
Alaska	76	130	----------	----------	----------	--------
Arizona	95,682,778	4,697,394	498	2,999	194	89
California	84	581	6,112	85,900	12	279
Colorado	1,397	2,324	1,924	24,453	257,871	147,895
Idaho	32,355	2,967	160,949	1,880,457	44,845	56,937
Michigan	7,540,980	472,813	----------	----------	----------	--------
Missouri	----------	----------	6,355,777	340,856	----------	--------
Montana	10,079,795	1,456,742	5,514	110,036	14,551	162,416
Nevada	10,671,047	424,336	9,191	36,283	1,151	1,424
New Mexico	6,687,066	114,766	43	97	245,454	45,157
New York	----------	----------	----------	----------	605,717	27,615
Oregon	846	291	----------	----------	----------	--------
South Dakota	----------	----------	----------	----------	----------	--------
Tennessee	----------	----------	----------	----------	----------	--------
Utah	28,344,008	2,254,482	432	4,605	42	17
Other States [5]	210,950	15,990	----------	----------	477,079	36,376
Total	159,251,382	9,442,816	6,540,440	2,485,686	1,646,916	478,205
Percent of total silver	----------	29	----------	8	----------	1

State	Lode—continued						Refinery
	Lead-zinc copper-zinc, and copper-lead-zinc ores		Old tailing, etc.		Total		Troy ounces of silver
	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	Short tons	Troy ounces of silver	
Alaska	--------	--------	------	------	176	3,900	3,450
Arizona	120,656	192,681	46,016	[1] 25,693	95,953,958	[1] 4,958,162	5,149,040
California	63,297	411,654	285	[2] 69,028	76,289	[2] 597,961	292,700
Colorado	720,015	1,272,899	1,788	33,805	1,056,126	1,646,283	1,454,600
Idaho	666,670	1,887,522	325,474	265,889	1,710,091	15,958,715	15,466,400
Michigan	--------	--------	------	------	7,540,980	472,813	332,100
Missouri	--------	--------	------	------	6,355,777	340,856	395,900
Montana	952	4,612	46,759	59,484	10,215,185	2,132,571	2,802,000
Nevada	70,304	153,820	20	588	10,779,621	645,192	561,900
New Mexico	65,299	13,751	46	173	7,001,408	224,866	271,900
New York	--------	--------	------	------	605,717	27,615	27,600
Oregon	--------	--------	------	------	863	335	170
South Dakota	--------	--------	------	------	1,921,653	137,668	137,100
Tennessee	1,624,400	89,525	------	------	1,624,400	89,525	82,500
Utah	556,344	2,717,033	35,753	[1] 75,925	29,078,515	[1] 5,120,772	4,300,000
Other States [5]	197,886	[3] 27,739	------	------	962,563	[3] 371,745	422,640
Total	4,085,823	6,771,236	456,141	530,585	174,883,322	32,728,979	31,700,000
Percent of total silver	--------	21	------	2	----------	100	--------

---

[1] Includes byproduct silver recovered from uranium ore.

[2] Includes byproduct silver recovered from tungsten ore.

[3] Includes byproduct silver recovered from magnetite-pyrite ore.

[4] Less than ½ unit.

[5] Includes Kentucky, Texas, Washington, and Wisconsin.

Table 5.—Mine production of recoverable silver in the United States, by States

(Troy ounces)

State	1964	1965	1966	1967	1968
Alaska	7,336	7,673	7,193	5,787	3,900
Arizona	5,810,510	6,095,285	6,338,696	4,588,081	4,958,162
California	171,621	196,787	189,989	144,515	597,961
Colorado	2,626,431	2,051,105	2,085,534	1,817,699	1,646,283
Idaho	16,483,495	18,456,809	19,776,785	17,033,330	15,958,715
Kentucky	1,673	1,931	1,086	568	-----------
Maine	-----------	-----------	-----------	-----------	[1] 371,745
Michigan	349,195	457,851	483,000	301,992	472,813
Missouri	-----------	299,522	-----------	r 226,168	340,856
Montana	5,289,959	5,207,031	5,319,785	2,066,464	2,132,571
Nevada	172,447	507,113	867,567	565,755	645,192
New Mexico	242,405	287,472	242,620	157,495	224,866
New York	13,306	11,441	21,590	31,103	27,615
Oklahoma	-----------	[2] 358,477	[2] 368,788	[2] 279,898	(1)
Oregon	14,372	8,801	343	31	335
Pennsylvania	[3] 375,603	(2)	(2)	(2)	(1)
South Dakota	132,981	128,971	109,885	121,258	137,668
Tennessee	90,539	94,142	100,716	130,078	89,525
Utah	4,551,960	5,635,570	7,755,411	4,874,640	5,120,772
Washington	(3)	(2)	(2)	(2)	(1)
Wyoming	28	52	-----------	-----------	-----------
Total	36,333,861	39,806,033	43,668,988	r 32,344,862	32,728,979

r Revised.

[1] Production of Maine, Oklahoma, Pennsylvania, and Washington combined to avoid disclosing individual company confidential data.

[2] Production of Oklahoma, Pennsylvania, and Washington combined to avoid disclosing individual company confidential data.

[3] Production of Pennsylvania and Washington combined to avoid disclosing individual company confidential data.

Table 6.—Silver produced in the United States from ore, old tailings, etc., in 1968 by States and methods of recovery, in terms of recoverable metal[1]

State	Total ore, old tailings etc.,[2] treated (thousand short tons)	Ore and old tailings to mills					Crude ore, old tailings, etc., to smelters	
		Thousand short tons [2]	Recoverable in bullion		Concentrates smelted and recoverable metal			
			Amalgamation (troy ounces)	Cyanidation (troy ounces)	Concentrates (short tons)	Troy ounces	Thousand short tons	Troy ounces
Alaska	(3)	--------	--------	--------	59	2,571	------	--------
Arizona	96,196	95,799	--------	--------	2,507,093	4,791,191	397	166,971
California	76	70	738	100	15,215	500,757	7	96,045
Colorado	1,056	1,048	832	--------	141,078	1,481,046	8	164,185
Idaho	1,710	1,647	22	--------	191,534	15,866,840	64	91,853
Michigan	8,027	8,027	--------	--------	240,576	472,813	------	--------
Missouri	6,356	6,356	--------	--------	341,329	340,856	------	--------
Montana	10,215	10,099	2	--------	248,056	1,690,040	116	442,529
Nevada	11,650	11,555	170	--------	280,281	597,513	95	47,475
New Mexico	7,001	6,958	--------	--------	302,198	173,674	44	51,157
New York	785	785	--------	--------	126,761	27,615	------	--------
Oregon	1	1	1	--------	69	164	(3)	170
South Dakota	1,922	1,922	90,256	46,660	--------	----------	------	--------
Tennessee	5,969	5,969	--------	--------	299,307	89,525	------	--------
Utah	29,079	28,878	--------	--------	810,882	4,610,784	201	509,988
Other States	962	962	--------	6,906	69,730	364,329	(3)	510
Total	181,005	180,076	92,021	53,666	5,574,168	31,009,718	932	1,570,883

[1] Data may not add to total shown because of independent rounding.

[2] Includes some non-silver-bearing ores not separable; excludes tonnage of magnetite-pyrite, tungsten, and uranium ores from which silver was recovered as a byproduct.

[3] Less than ½ unit.

Table 7.—Silver produced at amalgamation and cyanidation mills in the United States and percentage of silver recoverable from all sources

Year	Bullion and precipitates recoverable (troy ounces)		Silver recoverable from all sources (percent)			
	Amalgamation	Cyanidation	Amalgamation	Cyanidation	Smelting [1]	Placers
1964	91,401	120,894	0.25	0.33	99.39	0.03
1965	167,331	48,632	.42	.12	99.44	.02
1966	80,033	41,098	.18	.09	99.71	.02
1967	84,290	47,054	.26	.15	99.57	.02
1968	92,021	53,666	.28	.16	99.55	.01

[1] Crude ores and concentrates.

Table 8.—Silver produced at refineries in the United States, by source

(Thousand troy ounces)

	1967	1968
From concentrates and ores:		
Domestic	30,268	42,052
Foreign	23,777	31,222
Total	54,045	73,274
From old scrap	33,534	57,466
From new scrap	25,361	34,602
Total production	112,940	165,342

Table 9.—U.S. consumption of silver, by end use

(Thousand troy ounces)

	1967	1968
Electroplated ware	17,897	15,279
Sterling ware	30,269	28,349
Jewelry	5,751	4,538
Photographic materials	50,306	41,607
Dental and medical supplies	2,690	3,094
Mirrors	2,174	1,744
Brazing alloys and solders	15,391	15,124
Electrical and electronic products:		
Batteries	11,405	5,764
Contacts and conductors	26,777	25,805
Rocket nozzles	-----------	---------
Catalysts	5,847	2,310
Bearings	600	451
Miscellaneous [1]	1,925	1,228
Total net industrial consumption	171,032	145,293
Coinage	43,851	36,833
Total consumption	214,883	182,126

[1] Includes silver-bearing copper, silver-bearing lead anodes, ceramic paints, etc.

Table 10.—Value of silver exported from and imported into the United States

(Thousand dollars)

Year	Exports	Imports
1966	$110,533	$76,187
1967	95,960	77,087
1968	247,100	137,800

Table 11.—U.S. exports of silver in 1968, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore and base bullion		Refined bullion		United States coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
Argentina	---------	---------	---------	---------	---------	$7
Australia	---------	---------	---------	---------	---------	1
Austria	---------	---------	9	$19	---------	---------
Bahamas	262	$430	109	185	---------	---------
Belgium-Luxembourg	7,280	14,270	5,509	13,061	---------	632
Brazil	---------	---------	183	416	---------	---------
Canada	306	635	7,178	14,758	$1	1,115
Colombia	2	4	29	65	---------	---------
Denmark	---------	---------	256	598	---------	204
France	---------	---------	9,107	17,291	---------	142
Germany, West	2,355	4,970	827	1,731	---------	63
Hong Kong	---------	---------	---------	---------	---------	3
Israel	9	23	---------	---------	---------	---------
Italy	87	160	311	755	---------	1,887
Japan	34	85	2,038	4,418	---------	(1)
Lebanon	---------	---------	---------	---------	---------	50
Mexico	---------	---------	10,047	12,990	(1)	17
Netherlands	15	32	4,857	9,797	---------	25
Netherlands Antilles	---------	---------	---------	---------	3	---------
Norway	34	74	---------	---------	---------	8
Peru	---------	---------	409	816	---------	---------
Spain	170	341	152	274	---------	---------
Sweden	1,320	2,954	---------	---------	---------	---------
Switzerland	484	958	15,978	35,206	3	94
United Kingdom	10,771	22,613	45,633	87,171	6	785
Total	23,129	47,549	102,632	199,551	13	5,033

[1] Less than ½ unit.

Table 12.—U.S. imports of silver in 1968, by countries

(Thousand troy ounces and thousand dollars)

Country	Ore and base bullion		Refined bullion		United States coin value	Foreign coin value
	Quantity	Value	Quantity	Value		
Argentina	107	$170	---------	---------	---------	---------
Australia	1,267	2,189	266	$634	---------	---------
Austria	---------	---------	101	250	---------	$2
Bahamas	---------	---------	---------	---------	---------	3
Belgium-Luxembourg	86	156	555	1,166	---------	4
Bolivia	1,102	1,787	---------	---------	---------	---------
Bulgaria	---------	---------	---------	---------	---------	(1)
Canada	13,555	24,634	26,052	56,989	---------	94
Chile	1,897	2,102	297	647	---------	---------
Colombia	1	1	---------	---------	---------	12
Ecuador	13	21	---------	---------	---------	3
El Salvador	---------	---------	3	4	---------	---------
France	---------	---------	---------	---------	---------	2
Germany, West	3	6	1	1	(1)	7
Honduras	3,544	5,774	194	432	---------	10
Ireland	---------	---------	---------	---------	---------	215
Israel	---------	---------	---------	---------	---------	189
Japan	---------	---------	133	319	---------	---------
Korea, South	---------	---------	97	234	---------	---------
Liberia	---------	---------	---------	---------	---------	850
Mexico	1,429	2,928	8,916	16,705	$37	4,453
Netherlands	---------	---------	---------	---------	---------	2
Nicaragua	156	283	8	17	---------	---------
Norway	16	24	---------	---------	---------	---------
Panama	25	57	11	17	---------	1,418
Paraguay	---------	---------	---------	---------	---------	1
Peru	4,520	7,802	1,286	2,872	---------	---------
Philippines	358	687	42	58	---------	1
South Africa, Republic of	707	966	328	756	---------	---------
Switzerland	---------	---------	3	8	---------	18
United Arab Republic	---------	---------	---------	---------	---------	6
United Kingdom	---------	---------	3,380	6,629	---------	7
U.S.S.R.	---------	---------	170	333	---------	---------
Uruguay	---------	---------	---------	---------	---------	18
Venezuela	---------	---------	(1)	1	---------	---------
Yugoslavia	---------	---------	80	141	---------	---------
Total	28,786	49,587	41,923	88,213	37	7,315

[1] Less than ½ unit.

Table 13.—World production of silver, by countries[1]

(Thousand troy ounces)

Country[2]	1964	1965	1966	1967	1968[p]
North and Central America:					
Canada	29,903	[r] 32,272	[r] 32,825	36,315	45,621
Haiti	92	77	51	[e] 34	13
Honduras	3,220	3,671	3,734	4,009	4,397
Mexico	41,716	40,332	41,983	37,939	40,031
Nicaragua	332	380	447	372	416
United States	36,334	39,806	43,669	32,119	32,729
South America:					
Argentina	1,943	2,286	2,207	NA	NA
Bolivia	4,811	4,114	5,124	4,515	5,180
Brazil	314	228	222	225	464
Chile	3,097	2,972	3,610	3,156	3,757
Colombia	131	116	109	110	100
Ecuador	117	70	77	80	136
Peru	34,419	36,470	32,841	35,870	36,020
Europe:					
Austria	74	77	93	126	161
Czechoslovakia [e]	2,400	2,400	2,400	2,400	NA
Finland	608	582	520	623	677
France	969	1,401	2,008	2,163	[e] 2,000
Germany:					
East [e]	4,800	4,800	4,800	4,800	4,800
West	2,063	2,022	2,018	2,042	[e] 2,000
Greece	154	139	138	232	261
Ireland	---------	[r] 1,218	1,219	2,067	1,913
Italy	1,074	1,103	1,132	1,382	1,156
Poland [e]	129	129	160	160	160
Portugal	49	[r] 93	355	357	300
Rumania [e]	643	643	[r] 750	800	800
Spain[3]	2,315	1,961	2,025	2,218	[e] 2,400
Sweden	[r] 3,122	[r] 3,409	[r] 3,517	3,455	3,524
U.S.S.R.[e]	29,000	31,000	33,000	35,000	35,000
Yugoslavia	4,037	4,148	3,651	3,075	2,577
Africa:					
Algeria	295	295	[r] 110	100	100
Congo (Kinshasa)	1,480	1,538	1,851	1,840	2,139
Kenya	48	21	19	3	3
Morocco	604	599	707	773	920
Rhodesia, Southern	88	[e] 95	[e] 95	NA	NA
South Africa, Republic of	2,917	3,132	3,134	3,064	3,337
South-West Africa, Territory of[4]	1,436	1,541	1,517	1,450	1,350
Tanzania	25	23	11	2	2
Tunisia	13	34	38	45	[e] 46
Zambia[5]	1,446	849	[e] 750	[e] 750	[e] 768
Asia:					
Burma	1,867	1,638	[r] 1,063	917	780
China, mainland [e]	800	800	800	600	700
India	152	168	39	112	81
Indonesia	253	299	221	309	309
Japan	8,715	8,989	10,319	10,800	10,713
Korea:					
North [e]	650	650	650	700	700
South	404	434	499	588	611
Philippines	908	934	1,163	1,396	1,575
Taiwan	[r] 67	[r] 96	[r] 87	127	85
Oceania:					
Australia	18,427	17,281	[r] 18,888	19,783	21,618
Fiji	61	60	67	61	55
New Guinea and Papua	23	20	18	17	18
New Zealand	(6)	(6)	(6)	---------	4
Total[7]	[r] 248,545	[r] 257,415	[r] 266,731	259,081	272,507

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Recoverable content of ores and concentrates produced unless otherwise noted.

[2] Silver is also produced in Bulgaria, Guatemala, Hungary, Thailand, Turkey, and several African countries. Quantities are insignificant or not reported.

[3] Smelter and/or refinery production.

[4] Recoverable silver content of Tsumeb Corp. Ltd. concentrates, as reported for year ending June 30 of year stated.

[5] Includes recovery from copper refinery sludges.

[6] Less than ½ unit.

[7] Total is of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/70

Slag—Iron and Steel

By John W. Thatcher[1]

Demand for iron-blast-furnace slag products in 1968 equaled available supplies. Although there was a slight reduction in the tonnage and dollar value of blast-furnace slag marketed in 1968, this was more than offset by an increase in the amount of steel slag used. Decreased availability of blast-furnace slag and rapidly changing iron and steel making technology have caused an increased interest in using steel slags, either alone or blended with blast-furnace slag, for roadway base and fill, in bituminous mixtures, for railroad ballast, in agriculture, and for miscellaneous uses.

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Iron-blast-furnace slag processed in the United States, by types

(Thousand short tons and thousand dollars)

Year	Air-cooled				Granulated		Expanded		Total	
	Screened		Unscreened							
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1964	20,969	$36,458	621	$599	2,840	$2,170	2,426	$7,273	26,856	$46,500
1965	22,531	39,624	1,402	1,270	3,550	[1] 2,674	2,596	7,879	30,079	51,447
1966	19,925	35,348	551	588	3,749	[1] 3,026	2,525	7,860	26,750	46,822
1967	22,326	39,204	1,052	800	3,760	[1] 2,834	2,456	7,262	29,593	50,101
1968	21,757	39,034	1,826	1,493	2,944	[1] 2,631	2,215	6,251	28,742	49,408

[1] Excludes value of slag used for manufacturing hydraulic cement 1965–68; and granulated aggregate for concrete-block manufacturing 1966–68.

Source: National Slag Association.

Table 2.—Iron-blast-furnace slag processed in the United States, by States

(Thousand short tons and thousand dollars)

Year and State	Screened air-cooled		All types	
	Quantity	Value	Quantity	Value
1967				
Ohio	4,029	$7,684	5,868	$10,211
Pennsylvania	7,134	13,051	9,082	15,412
Illinois, Indiana, Michigan	4,642	7,391	6,519	11,001
Other States [1]	6,521	11,078	8,124	13,477
Total	22,326	39,204	29,593	50,101
1968				
Ohio	4,175	8,208	5,994	11,571
Pennsylvania	5,728	11,251	7,398	13,751
Illinois, Indiana, Michigan	4,808	7,759	6,472	9,776
Other States [1]	7,046	11,817	8,878	14,309
Total	21,757	39,034	28,742	49,408

[1] Alabama, California, Colorado, Kentucky, Maryland, Minnesota, New York, Texas, Utah, and West Virginia.

Source: National Slag Association.

Table 3.—Shipments of iron-blast-furnace slag in the United States by methods of transportation

Method of transportation	1967		1968	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Rail	6,798	23	6,334	22
Truck	22,070	74	21,478	75
Waterway	725	3	718	3
Total	29,593	100	28,530	100

Source: National Slag Association.

DOMESTIC PRODUCTION

Production and value of all types of iron-blast-furnace slag decreased about 3 percent and 1 percent, respectively, from those for 1967. The drop in production was attributed to less slag being available from old banks built up during previous years and to yearly fluctuations in construction demands. A total of 30 companies operated 56 air-cooled, 17 expanded, and 14 granulated-slag plants in 1968, compared with 39 companies operating 61 air-cooled, 14 expanded, and 14 granulated-slag plants in 1967. Slag-encrusted iron, reclaimed magnetically by the slag processors for remelting, amounted to 630,092 short tons, compared with 613,109 tons in 1967. The industry's 1,620 plant and yard employees worked a total of 3.9 million man-hours in 1968. Production per man-hour decreased from 7.6 tons in 1967 to 7.4 tons in 1968.

The amount of steel slags processed in 1968 increased sharply, and because of the availability and satisfactory performance of steel slags, this trend is expected to continue. It was estimated that at least 12 million tons of steel slag were processed in 1968, including 6.2 million tons by members of the National Slag Association. This is about a 20-percent gain over the amount processed in 1967.

CONSUMPTION AND USES

Screened air-cooled slag accounted for 76 percent of the total quantity of blast-furnace slag sold or used in 1968. Consumption of other types was as follows: Unscreened air-cooled, 6 percent; granulated, 10 percent; and expanded, 8 percent. Of the total blast-furnace slag sold or used, more than 91 percent went to products used in the construction or maintenance of roads, buildings, railroads, or airports, or into construction accessories such as mineral wool. The balance was used in glass manufacture, as a sewage trickling filter medium, or as agricultural slag. Noteworthy shifts in the slag consumption pattern in 1968 were an increase in the use of screened air-cooled slag in pavements, roofing, construction and sewage systems, and an increase in the use of expanded slag in lightweight concrete. The amount of blast-furnace slags used as an aggregate in the manufacture of concrete blocks dropped 33 percent from that used in 1967.

In view of the increasing emphasis on highway safety, an article concerning the construction and performance aspects of the Indianapolis Speedway was particularly significant. The slag-sand overlay, applied to the 2½-mile track in 1962, reportedly "never gets slick" and has easily withstood the punishment and stress of racing cars traveling at speeds up to 200 miles per hour.[2] An article was published describing the advantages of using a slag slurry seal to rejuvenate old roads in the Buffalo, N.Y. area.[3] The role of blast-furnace slag in the construction of a $500-million steel plant by Bethlehem Steel Corp. at Burns Harbor, Indiana, was described.[4]

---

[2] Engineering News-Record. Speedway Faster Than Ever After 60 Years. V. 181, No. 22, May 30, 1968, pp. 26–27.

[3] Constructioneer (South Edition). Old Roads Get New Life With Slag Slurry Seal. Nov. 25, 1968, pp. 32–34.

[4] Rock Products. Bethlehem Plant To Use 500,000 Tons of Slag. V. 70, No. 12, December 1967, p. 114.

Table 4.—Air-cooled iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1967				1968			
	Screened		Unscreened		Screened		Unscreened	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Aggregate in:								
Portland-cement concrete construction:								
Structures	1,461	$2,959	-----	-----	1,284	$2,461	1	$1
Pavements	933	2,628	-----	-----	1,378	2,899	-----	-----
Bituminous construction (all types)	3,462	6,387	-----	-----	3,661	6,929	249	109
Highway and airport construction [1]	10,013	16,647	275	$337	9,282	16,785	94	110
Manufacture of concrete block	426	739	-----	-----	264	464	-----	-----
Railroad ballast	4,103	5,908	-----	-----	4,223	6,149	-----	-----
Mineral wool	389	613	-----	-----	390	612	26	20
Roofing slag:								
Cover material	425	1,262	-----	-----	352	1,061	-----	-----
Granules	48	224	-----	-----	167	328	-----	-----
Sewage trickling filter medium	7	13	-----	-----	24	40	-----	-----
Agricultural slag, liming	2	3	-----	-----	2	3	-----	-----
Other uses	1,057	1,821	777	463	731	1,304	1,457	1,253
Total	22,326	39,204	1,052	800	21,757	39,034	1,826	1,493

[1] Other than in portland-cement concrete and bituminous construction.

Source: National Slag Association.

Table 5.—Granulated and expanded iron-blast-furnace slag sold or used by processors in the United States, by uses

(Thousand short tons and thousand dollars)

Use	1967				1968			
	Granulated		Expanded		Granulated		Expanded	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Highway construction and fill (road, etc.)	1,952	$2,440	-----	-----	1,643	$2,309	-----	------
Agricultural slag, liming	69	115	-----	-----	59	107	-----	------
Manufacture of hydraulic cement	1,210	NA	-----	-----	914	NA	-----	------
Lightweight concrete	-----	------	320	$968	-----	------	718	$2,233
Aggregate for concrete-block manufacture	367	NA	2,061	6,030	131	NA	1,438	3,809
Other uses	261	279	75	264	197	215	59	209
Total	3,760	[1] 2,834	2,456	7,262	2,944	[1] 2,631	2,215	6,251

NA Not available.

[1] Excludes value for manufacture of hydraulic cement and granulated aggregate for concrete-block manufacture 1967–68.

Source: National Slag Association.

Table 6.—Steel slag sold or used by processors in the United States, in 1968, by uses[1]

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Railroad ballast	792	$709
Highway base or shoulders	1,665	1,600
Paved-area base	1,171	925
Miscellaneous base or fill	1,390	1,253
Bituminous mixes	479	645
Agricultural	85	296
Other uses	627	469
Total	6,209	5,897

[1] Does not include tonnage returned to furnaces for charge material.

Source: National Slag Association.

PRICES

The average value reported for total blast-furnace slag production increased from $1.69 per ton in 1967 to $1.72 per ton in 1968. However, because slag with diverse characteristics was produced for a variety of uses, values ranged from $0.60 per ton for material which received little processing to $3.52 per ton for smaller quantities of slag which required a high degree of screening, sizing, and washing to meet rigid specifications.

Prices for crushed slag (air-cooled, screened) used as aggregate were published monthly for major U.S. market areas in Engineering News-Record. In December 1968, quoted prices ranged from $1.16 to $2.50 per ton for both 1½-inch and ¾-inch crushed slag.

Table 7.—Average value of iron-blast-furnace slag sold or used by processors in the United States, by uses

(Per short ton)

Use	Air-cooled				Granulated		Expanded	
	Screened		Unscreened					
	1967	1968	1967	1968	1967	1968	1967	1968
Agregate in:								
Portland-cement concrete construction	$2.33	$2.01	-----	-----	-----	-----	-----	-----
Bituminous construction (all types)	1.84	1.89	-----	-----	-----	-----	-----	-----
Highway and airport construction [1]	1.65	1.80	$1.23	$1.16	$1.25	$1.40	-----	-----
Manufacture of concrete block	1.73	1.76	-----	-----	1.41	1.80	$2.92	$2.65
Railroad ballast	1.44	1.45	-----	-----	-----	-----	-----	-----
Mineral wool	1.58	1.58	-----	-----	-----	-----	-----	-----
Roofing slag:								
Cover material	3.00	3.00	-----	-----	-----	-----	-----	-----
Granules	4.65	4.65	-----	-----	-----	-----	-----	-----
Sewage trickling filter medium	1.97	1.64	-----	-----	-----	-----	-----	-----
Agricultural slag, liming	1.87	1.58	-----	-----	1.57	1.80	-----	-----
Other uses	1.73	1.78	.60	.86	1.06	1.69	[2] 3.58	[2] 3.52

[1] Other than in portland-cement and bituminous construction.
[2] Does not include slag for use in lightweight concrete valued at $3.04 per ton in 1967 and $3.11 per ton in 1968.

Source: National Slag Association.

TECHNOLOGY

A process developed by the British firm, Fisons Ltd., for upgrading basic slag from steel making is of special interest to steel producers and slag processors in countries where basic slag sold as fertilizer must meet a certain minimum soluble phosphate specification. The process features a high-intensity magnetic separation technique which splits finely powdered slag into a phosphate-rich fraction and an iron-rich fraction. The former, containing 2 to 3 percent phosphate, is sold as fertilizer; the latter is recycled to the blast furnace.[5]

Research on slagceram continued in 1968 at the Chemistry Department of the British Iron and Steel Research Association (BISRA), London, England. Slagceram, first developed in 1965, is a product made by heating a mix of iron-blast-furnace slag, sand, and a nucleating agent such as chromium, titanium, or iron. From this, bricks, tiles, and wallblocks can be made which can be given a polish or enameled finish in a variety of colors and textures. With the aid of an electron microprobe it was determined that sulfur, in concentrations below that detectable by chemical analysis, plays a significant role in the heat-treating process, and thus is an important factor in the production economics of slagceram.[6]

The flow and blending of blast-furnace and open-hearth slag through four plants of Vulcan Materials Co.'s Southeast Division were described. The plants are located within 6 miles of each other in the Birmingham, Ala., area at Exum, Ensley, Fairfield and Wylam. Open-hearth slag is sized at the Exum Plant, then blended with blast-furnace slag at the Ensley and Fairfield Plants. Fines from Fairfield are shipped to Wylam for further processing and bagging. Source of the open-hearth slag is a 20-million ton waste slag pile at Exum, formed since the startup of U.S. Steel Corp.'s Fairfield Steel Works in 1910. Blast-furnace slag is obtained at Fairfield from adjacent hot pits and from a waste pit at U.S. Steel Corp.'s Ensley Works. Part of the blended aggregate product is consumed at the Fairfield site by a roofing granules facility and by an on-site customer's asphalt plant, and the rest is shipped to customers. Part of the open-hearth slag product at Exum does not enter the blending process but is shipped back to the steel plant for blast furnace sintering operations.[7]

---

[5] Chemical Engineering. V. 76, No. 3, Jan. 29, 1969, p. 27.
[6] BISRA Annual Report for 1968 (London). Process Chemistry, Slagceram, p. 38.

New product development and the resultant growth of a slag processing company were summarized, and a process for making headlap roofing granules from blast-furnace slag was described in detail. In addition to roofing granules, other products obtained from the process are a high-alumina content additive used in manufacturing glass bottles and a mineral filler used in fabricating sound deadening panels for the automotive industry.[8]

---

[7] Levine, Sidney. Open-Hearth Slag Produces New Aggregate Blends. Rock Products, v. 71, No. 5, May 1968, pp. 122–128.

[8] Pit & Quarry. New Products From Blast Furnace Slag. V. 60, No. 8, February 1968, pp. 94–98.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/194

Sodium and Sodium Compounds

By Benjamin Petkof [1]

Domestic production of sodium compounds increased slightly during 1968 with the proportion of total production derived from natural sources showing a marked increase. Green River, Wyo., continued to be the major production area for naturally derived soda ash to meet industrial requirements.

DOMESTIC PRODUCTION

Total output of natural and manufactured sodium carbonate (soda ash) rose very slightly in 1968. Production of manufactured material declined 6 percent, but production from natural sources increased 18 percent. Soda ash derived from natural sources increased to 31 percent of total production, which may indicate increasing industrial reliance on natural material.

Soda ash derived from natural sources was produced in California from dry lake brines and in Wyoming from underground bedded trona deposits. California producers were American Potash and Chemical Corp., PPG Industries, Inc., and Stauffer Chemical Co. Early in 1968 Pittsburgh Plate Glass terminated production. Wyoming producers were Allied Chemical Corp., Inorganic Chemicals Division of FMC Corp., and Stauffer Chemical Co. of Wyoming.

Total production of manufactured and natural sodium sulfate increased 8 percent from that of 1967. About 48 percent of the total output was produced from natural sources at three operations in Texas, three in California, and one in Wyoming.

In California, American Potash and Chemical Corp. and Stauffer Chemical Co. recovered sodium sulfate from dry lake brines at the Trona and Westend plants, respectively, and United States Borax and Chemical Co. recovered sodium sulfate at plants in Wilmington and San Francisco. The Ozark-Mahoning Mining Company recovered salt cake from subterranean brines at its Brownfield, Monahans, and Seagraves operations in Texas. The William E. Pratt Sodium Co. removed a small quantity of sodium sulfate from dry lake beds near Casper, Wyo.

Sodium metal production declined from 163,448 short tons in 1967 to 156,859 tons in 1968. Sodium and its coproduct chlorine were produced by electrolysis of molten salt by three companies at five plants: E. I. du Pont de Nemours & Co., Inc., at Niagara Falls, N.Y., and Memphis, Tenn.; Ethyl Corp., at Baton Rouge, La., and Houston, Tex.; and Reactive Metals, Inc., at Ashtabula, Ohio.

Table 1.—Manufactured sodium carbonate produced and natural sodium carbonates sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Manufactured soda ash (ammonia-soda process)[1]	Natural sodium carbonates [2]	
	Quantity	Quantity	Value
1964	4,948	1,275	$30,451
1965	4,926	1,494	34,717
1966	[r] 5,071	1,738	40,674
1967	[r] 4,849	[r] 1,726	40,539
1968	[p] 4,553	2,043	42,104

[r] Revised. [p] Preliminary.

[1] Bureau of the Census. Includes quantities used to manufacture caustic soda, sodium bicarbonate, and finished light and dense soda ash.

[2] Soda ash and trona (sesquicarbonate).

---

[1] Physical scientist, Division of Mineral Studies.

Table 2.—Sodium sulfate produced and sold or used by producers in the United States

(Thousand short tons and thousand dollars)

Year	Production (manufactured and natural)[1]		Sold or used by producers (natural only)	
	Salt cake (crude)[2]	Anhydrous refined (100 percent Na_2SO_4)	Quantity	Value
1964	926	389	575	$10,989
1965	976	428	620	11,024
1966	1,009	436	640	11,271
1967	^{r} 945	^{r} 419	637	10,710
1968	^{p} 1,063	^{p} 409	700	12,729

^{r} Revised, ^{p} Preliminary.

[1] Bureau of the Census.

[2] Includes production of glauber salt converted to 100 percent Na_2SO_4.

CONSUMPTION AND USES

The consumption and use pattern of sodium carbonate, sodium sulfate, and sodium metal remained relatively unchanged from previous years. About two-fifths of total sodium carbonate production was used in the production of glass, about one-fourth in chemicals, and about one-tenth in pulp and paper. The remainder was used for miscellaneous purposes such as soap and detergents, aluminum production, and water treatment.

Kraft paper production continued to require the major portion of sodium sulfate production. Sodium sulfate was used also in the manufacture of glass, ceramic glazers, detergents, stockfeeds, dyes, textiles, medicines, and miscellaneous chemicals.

Metallic sodium was used primarily in the production of tetraethyl and tetramethyl lead compounds, which are used as additives to motor fuels to improve their antiknock qualities. Possible areas for future increased consumption of sodium metal are in the reduction of titanium tetrachloride to titanium, the sodium sulfate battery for electric cars; polyethylene-clad, sodium cored electrical conduction cable and sodium-cooled breeder-type nuclear reactors.

PRICES

Prices of sodium compounds showed some variation during the year. Price quotations during 1968 in the Oil, Paint and Drug Reporter were as follows:

Compound	Price
Sodium carbonate (soda ash 58 percent Na_2O):	
Light, paper bags, carlots, works per hundred weight	$2.05
Light, bulk, carlots, works do	1.55
Dense, paper bags, carlots, works do	2.15
Dense, bulk, carlots works do	1.60
Sodium sulfate (100 percent Na_2SO_4):	
Technical detergent, rayon grade, bags, carlots, works do	40.00
Technical detergent, rayon grade, bulk, works do	38.00
Domestic salt cake, bulk, works[1] do	28.00
National Formulary (N.F. VII), drums per pound	.23
Metallic sodium:	
Bricks, carlots, works do	.24
Fused, lots of 18,000 pounds and more, works do	.23
Bulk, tank, works do	.18

[1] Delivered east of the Mississippi River.

FOREIGN TRADE

Exports of sodium sulfate doubled in 1968 with almost three-fourths of the material going to Canada, Mexico, and Japan. Almost 4 percent of total sodium sulfate production was exported compared with about 2 percent in 1967.

Exports of sodium carbonate declined 5 percent from those of the previous year and represented about 4 percent of domestic production. Almost three-fifths of total exports were destined for Canada. Varying smaller quantities went to other nations.

Imports of sodium sulfate increased 5 percent over those of the previous year with all of the material coming from Canada, Belgium-Luxembourg, West Germany, and Netherlands.

At the yearend new tariff rates were established for imports of sodium compounds effective January 1, 1969, as follows:

	Tariff rate per short ton
Sodium carbonate:	
Calcined (soda ash)	$4.00
Hydrated and sesquicarbonate	4.00
Sodium sulfate:	
Crude (salt cake)	Free
Anhydrous	.40
Crystallized (glauber salt)	.80

Table 3.—U.S. exports of sodium carbonate and sodium sulfate

(Thousand short tons and thousand dollars)

Year	Sodium carbonate		Sodium sulfate	
	Quantity	Value	Quantity	Value
1966	346	$12,249	28	$779
1967	304	9,914	28	856
1968	288	9,181	56	1,844

Table 4.—U.S. imports for consumption of sodium sulfate

(Thousand short tons and thousand dollars)

Year	Crude (salt cake)		Anhydrous		Total [1]	
	Quantity	Value	Quantity	Value	Quantity	Value
1966	228	$3,769	13	$205	237	$3,981
1967	273	4,312	15	190	r 289	r 4,508
1968	279	4,721	25	377	305	5,108

r Revised.

[1] Includes glauber salt, as follows: 1966, 602 tons ($6,981); 1967, r 662 tons r $5,948; 1968, 1,277 tons ($10,107).

WORLD REVIEW

Canada.—The western Canadian sodium sulfate industry has expanded to meet the requirements of the kraft pulp industry. Almost all of Canada's sodium sulfate is used as a chemical in the production of kraft pulp and paper. Sodium sulfate production in Saskatchewan increased to 469,076 tons in 1968 and was valued at $8 million. With eight plants in operation, including one new plant per year, Canadian production capacity reached 800,000 tons per year.[2]

Colombia.—Exports of sodium carbonate to Peru and Chile were initiated from a plant at Cartagena on the Atlantic coast. The plant has a production capacity of 82,000 tons per year and uses sea salt and limestone as starting materials.[3]

---

[2] Canadian Mining Journal. V. 90, No. 2, February 1969, p. 125.

[3] European Chemical News (London). Colombia Exports Sodium Carbonate. V. 13, No. 320, Mar. 22, 1968, p. 8.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/177

Stone

By Paul L. Allsman [1]

Domestic production of stone in 1968 was 819 million tons valued at $1.32 billion, compared with 786 million tons valued at $1.24 billion in 1967. Production of dimension stone in 1968 rose 72 percent in tonnage and 4 percent in value from 1967 levels. Dimension stone represented .4 percent of the tonnage and 7.6 percent of the total stone value.

Crushed stone production rose 4 percent in tonnage and 6 percent in value compared with 1967 levels. Main uses of crushed stone were as concrete aggregate and roadstone, 64 percent; cement manufacture, 13 percent; riprap, 3 percent; agricultural stone; (agstone), 5 percent; lime and deadburned dolomite manufacture, 4 percent; fluxstone, 4 percent; and railroad ballast, 2 percent.

Legislation and Government Programs.—Regulations concerning depletion allowances as they pertain to the stone industries were summarized for the National Limestone Institute during 1968. Important regulations are summarized below:

Size reduction is specifically considered not to alter the inherent mineral content; consequently crushed limestone is in the general classification of crude mineral products. Other processes allowable as crude mineral treatment include sorting, concentrating, and sintering, including processes incidental to these. Specific processes include all mineral dressing methods and flotation, crushing and coarse grinding for limestone, dolomite, granite, marble, and other stone. Specifically excluded is fine grinding.[2]

Table 1.—Salient stone statistics in the United States [1]

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
Shipped or used by producers:					
Dimension stone	2,545	2,403	2,327	2,011	3,457
Value	$96,970	$92,235	$89,814	$95,472	$99,648
Crushed stone	723,038	777,839	811,047	783,581	815,946
Value	$1,037,594	$1,111,596	$1,170,901	$1,144,772	$1,218,105
Total stone	725,583	780,242	813,374	785,592	819,403
Value	$1,134,564	$1,203,831	$1,260,715	$1,240,244	$1,317,753
Exports (value)	$6,796	$7,599	$9,442	$9,400	$9,969
Imports for consumption (value)	$23,753	$20,414	$20,739	$19,823	$24,628

[1] Includes slate.

DIMENSION STONE

DOMESTIC PRODUCTION

Of the total quantity of dimension stone sold or used by producers in 1968, granite comprised 20 percent; limestone, 17 percent; sandstone, 9 percent; miscellaneous stone, 46 percent; slate, 4 percent; marble, 3 percent; and basalt, 1 percent. A 72 percent increase in production of dimension stone in 1968 was due entirely to increased use of miscellaneous rough block, irregular shaped stone, and rubble in construction, as urban reconstruction programs began to take effect notably in California.

---

[1] Mineral specialist, Division of Mineral Studies.

[2] Pit and Quarry. New Depletion Regulations for Limestone Producers. V. 61, No. 4, October 1968, pp. 81–83.

Jim Walter Corp. announced agreement to acquire the Georgia Marble Co., Atlanta, Ga. in a stock exchange. The transaction was valued at $23 million. Georgia Marble Co. produces structural marble and limestone, monumental marble, crushed stone and calcium products, at 14 plants and quarries in seven States. Landmark Granite Co. purchased a plant of the Georgia Marble Co.'s Continental Granite Division, in a separate transaction. The plant at Elberton, Ga., produces Royalty Blue Granite, Carolina pink and mahogany, and black granite.[3]

The importance of rising costs to dimension and monument stone producers was the subject of an article. Retailing, manufacturing, and tax costs have risen, while dealers have attempted to keep prices low to meet competition from other products.[4]

The Iowa Limestone Producers Association held its 23d annual convention in Des Moines. Highlights of the program included labor and tax legislation, highway and agricultural conservation programs, reclamation of surface-mined property, utilization of mining sites for other purposes, and an important panel on safe blasting procedures.[5] The Building Stone Institute held its Golden Anniversary Convention in Miami, Fla. Important topics on the program were automatic data processing, stone-faced precast applications, new markets for stone, new developments in building construction, architectural results, and a business seminar.[6]

CONSUMPTION AND USES

Consumption was higher in 1968 for all types of dimension stone except sandstone and slate. Tonnage of stone used in 1968 compared with 1967 was: granite, up 7 percent; limestone, up 7 percent; marble, up 20 percent; sandstone, 10 percent less; slate, the same as last year; miscellaneous stone, up 827 percent, largely in the low-priced irregular broken stone and rubble category.

Potential new uses for dimension stone were highlighted by an architectural marketing study. Esthetic selection and knowledge of stone by architects, builders preferences, sales efforts by stone companies, and availability of stone masons were listed as directly affecting consumption of stone. Possible standardization of physical and chemical tests of architectural stone, and their value as selling tools, were also surveyed.[7]

New varieties and uses of dimension stone attained prominence during the year. Bluestone, sawn into dimension slabs by Helderberg Bluestone and Marble, Inc., Unadilla, N.Y., was texturized by flame burning to provide a highly ornamental structural material for a library at Troy, N.Y.[8]

Modern construction systems and innovations may result in lower costs and consequent increased consumption of building stone. Development of prefabricated stone construction units was described.[9] Epoxy bonding systems are being widely used to assemble stone panels in the dimension stone industry. Construction of the new Indiana Convention-Exposition Center in Indianapolis, using only bonded panels of Indiana limestone, was described.[10]

A new publication on dimension stone was issued during the year. The work covers uses and properties of stone, known resources of interest, and quarrying, manufacturing, and technology of use of dimension stone.[11]

PRICES

Average values (dollars per ton) are listed below for dimension stone, as reported to the Bureau of Mines:

	Building		Monumental	Flagging
	Rough	Dressed	Rough and dressed	
Granite	$17.50	$73.00	$93.00	-----
Marble	48.00	200.00	265.00	-----
Limestone	15.00	42.00	------	$9.50
Sandstone	14.75	41.00	------	46.00
Slate	54.50	160.00	------	28.00
Miscellaneous	3.00	12.50	------	18.00

---

[3] Elberton Graniteer. Landmark Granite Company Begins Operations. V. 12, No. 3, Summer 1968, p. 9.

[4] Carr, Gordon D. Rising Costs. American Art in Stone, v. 68, No. 1, January 1968, pp. 9–10.

[5] Pit and Quarry. Iowa Limestone Producers Review Industry's Future. V. 60, No. 10, April 1968, pp. 122–129.

[6] Building Stone News. Golden Days Ahead: Register for 50th Anniversary Convention. V. 9, No. 3, September 1968, pp. 1, 4.

[7] Makens, James C. Part I—The Overlooked Architect: Part II—The Awareness Gap: Do Tests Aid the Building Stone Industry? Stone Mag., v. 88, Nos. 4, 5, 8; April, May, August 1968; pp. 20–21, 16–17, 19.

[8] Clift, Tom. Thermally Textured Bluestone Used in Dual Structural-Ornamental Role. Stone Mag., v. 88, No. 12, December 1968, pp. 6–10.

[9] Burrell, Jim. Prefabricated Stone Units Can Cut Overall Building Costs 10% to 40%. Stone Mag., v. 88, No. 9, September 1968, pp. 8–11.

[10] Stone Magazine. Bonded Panels Speed Construction of Convention Center. V. 88, No. 10, October 1968, pp. 8–10.

[11] Barton, William R. Dimension Stone. BuMines Inf. Circ. 8391, 1968, 147 pp.

FOREIGN TRADE

In 1968, Canada received 69 percent of U.S. building and monumental stone exports. The Bahamas received 4 percent and Mexico 5 percent.

Italy was the leading source of imports of dimension stone, 69 percent; followed by Canada and Portugal, with 9 percent each. Leading import items were polished marble, 32 percent; marble or onyx manufactures, 20 percent; block granite, 15 percent; nonroofing slate, 10 percent; and sawed travertine, 7 percent.

WORLD REVIEW

Greece.—Marble production should reach 300,000 tons-per-year within 5 years, double that of 1967. Best known producing localities are (white marble) Mount Pentelicon, Kozani, and Paros Island; Tenos Island (green marble), Mani (red marble), Skyros Island (multi-colored marble), and Vytina and the Peloponnese (black marble). Hellenic Marble, S.A., is studying the potential of the marble industry.

TECHNOLOGY

Flame channeling for cutting quarry minerals has nearly replaced mechanical channelers. Use of compressed air in place of pure oxygen has affected significant cost reductions. Channels are burned up to 25 feet depth and lengths well over 100 feet.[12]

Wire sawing was the subject of a special two-part article by the Electro Minerals Division of The Carborundum Co. Different sizes of wires and abrasive grades are used for different lengths of cuts. Operational factors which affect sawing efficiency were examined. Skillful sawing may produce finishing and polishing effects in cut stone.[13]

Diamond blades are often used for cutting granite building blocks, because of its unusual hardness. Costs per square foot for cutting dimension stone were summarized:

	Cents
Granites (30 types)	65
Slate	12
High-silica sandstone	11
Dolomitic limestone	9
Marbles	8

Seventeen diamond wheels were studied by the Norton Co. Grinding Wheel Division, cutting many types of stone at the Vermont Marble Co. Plant, Rutland, Vt.[14]

A portable Model FA 200–A Browning Burner was adapted for use as a modern, efficient prospecting tool for dimension stone. The fuel-air channeler replaces the wedge and shim, channel bar and drilling, or portable oxygen tanks of the traditional prospecting outfit used for quarrying sample saw blocks.[15]

CRUSHED STONE

DOMESTIC PRODUCTION

Production of crushed stone reached a record high in 1968 of 816 million tons, 1 percent higher than the 1966 total of 811 million tons. The record year made up the 3 percent slump in tonnage of crushed stone produced in 1967. Crushed stone production has risen an average of 3 percent a year for the last five years, setting an enviable pace in the construction materials industry.

A number of plant descriptions were published during the year; modern engineering features were illustrated at several plants. San Xavier Rock and Materials Division added a new, automated concrete and block plant to its aggregate plant in Tucson, Ariz. Crushed stone and all other materials for a wide variety of ready mixed and concrete block products is produced locally.[16] Mechanization in the 55-foot-high limestone bed at W. S. Frey Co.'s Clearbrook, Va., quarry was described. Hydraulic-boom drills and scaling ladders are used to mine 45-foot-wide rooms in a 100-foot-thick deposit.[17] One of the industry's most efficiently engineered plants, General

---

[12] Browning, J. A. Compressed Air Powers Flame Channeller. Stone Mag., v. 88, No. 1, January 1968, p. 23.

[13] Fitch, Russell W. Wire Sawing—An Operator's Guide (Parts 1 and 2). Stone Mag., v. 88, Nos. 2, 3; February, March 1968, pp. 16–18; 18–21.

[14] Luce, Evan C. How To Evaluate and Predict Costs of Cutting Granite With Diamond Blades. Stone Mag., v. 88, No. 6, June 1968, pp. 21–23.

[15] Aston, R. Lee. New Prospecting Tool for Dimension Stone. Stone Mag., v. 88, No. 8, August 1968, p. 20.

[16] Papineau, Don. Tucson's Concrete Triangle. Modern Concrete, v. 32, No. 2, June 1968, pp. 48–53.

[17] Beck, Sidney E. Custom-Tailored Drills Meet Tough Roof Bolting Challenge. Rock Prod., v. 71, No. 9, September 1968, pp. 100–101.

Crushed Stone Co.'s 300-ton-per-hour installation at Skaneateles, N.Y., is completely utilized with full interchangeability of equipment, giving flexibility for peak production of any aggregate specification.[18]

The new 700-ton-per-hour crushed granite plant of Vulcan Materials Co. at Lithia Springs, Ga., has produced 16 screened aggregate sizes, eight of them at one time; fines are ponded or sold.[19] The modern 800-ton-hour aggregates plant of Standard Slag Co. at Marblehead, Ohio, on the site of a former dolomitic fluxstone plant, now produces premium concrete aggregates from the A and B limestone ledges underlying the dolomite.[20]

Limestone proved a versatile material, as the crushed stone industry made a great variety of products for engineering projects. Germany Valley Limestone Co. produced coal mine rockdust, high-purity stone for steel flux lime, limestone sand for glass manufacture, agricultural stone (agstone), chemical stone for paper pulp plants, and road metal at its Riverton, W. Va., operation.[21] Both crushed limestone and sand and gravel for the $1.2 billion Arkansas River Project are being produced by two new plants of W. D. Jeffrey, at Webbers Falls, Okla.; the stone plant will furnish any specification material, riprap, and agricultural limestone.[22]

Plant expansion was a notable trend as new construction projects and high-speed concreting schedules demanded additional aggregate tonnage. Surge piles enabled Curtis Construction Co. to meet aggregate demands as joint-venture contractors exceeded scheduled concrete yardage on the Little Goose Lock and Dam Project at Dayton, Wash.[23] Campbell Limestone Co. increased plant capacity at its Beverly, S.C., crushed granite plant to 1,200 tons per hour, and left room for expansion to 1,700 tons per hour, if demand warrants.[24] A new, modern 800-ton-per-hour granite gneiss aggregate plant was put onstream, to produce nine basic sizes of portland cement and bituminous concrete aggregates for the diversified interests of Glen Gardner Quarry Corp., Glen Gardner, N.J.[25]

CONSUMPTION AND USES

Consumption was higher for most kinds of crushed stone in 1968. Compared with last year, granite used was up 12 percent; calcareous marl dropped 1 percent; limestone rose 6 percent; marble rose 14 percent; sandstone dropped 1 percent; shell dropped 9 percent; traprock rose 7 percent; and miscellaneous stone dropped 40 percent. The most important uses were for road metal, 27 percent of the total in 1968; concrete aggregate, 17 percent; and cement manufacture, 13 percent.

The growing needs for agricultural limestone were forecast by the National Limestone Institute. Two to three times the amount of liming is needed as is actually used for various soil conditions in the U.S.[26] Agstone needs in Texas were estimated at 8 million tons, to correct soil acidity alone. Use of agricultural limestone in Australia was the subject of a feature article. Use of agstone is about one-tenth that in the United States per capita, but with unlimited potential for growth.[27]

Growing uses for aggregates were described, with the problems of acceptable specifications in producing them. Improved technology and equipment make possible meeting a greater number of contractor's specifications for aggregates.[28]

Growing use of ground marble as a filler in carpet backing was pointed up as the Georgia Marble Co. built a new calcium carbonate plant at Dalton, Ga. Forty different grades of marble whiting are produced.[29] Use of oystershell as a raw material for cement manufacture was described. Shell is very desirable for cement and lime manufacture, because of its high purity, when suitable oyster reef reserves are available.[30]

---

[18] Herod, Buren C. General Crushed Stone's Portable Plant Complex. Pit and Quarry, v. 61, No. 2, August 1968, pp. 72–76, 107.

[19] Trauffer, Walter E. New Georgia Crushed Granite Plant. Pit and Quarry, v. 6, No. 12, June 1968, pp. 70–75.

[20] Herod, Buren C. Standard Slag's Marblehead Plant. Pit and Quarry, v. 60, No. 9, March 1968, pp. 90–95.

[21] Levine, Sidney. High-Purity Limestone Generates Highly Profitable and Versatile Output. Rock Prod., v. 71, No. 8, August 1968, pp. 66–68.

[22] Pit and Quarry. New Crushed Stone Plant and Floating Sand Plant Supply Arkansas River Project. V. 60, No. 8, February 1968, pp. 113, 119.

[23] Pit and Quarry. Aggregate Plant Meets Heavy Concrete Schedule. V. 60, No. 12, June 1968, pp. 120–123.

[24] Trauffer, Walter E. Expansion of Campbell's Beverly Plant in South Carolina. Pit and Quarry, v. 61, No. 5, November 1968, pp. 66–77.

[25] Herod, Buren C. Young Firm Enters Industry With Outstanding New Plant. Pit and Quarry, v. 61, No. 2, August 1968, pp. 86–91.

[26] Smith, Arthur M. Pulverized Limestone—Tonnage Used Versus Estimated Needs. Comm. Fert. and Plantfood Ind., v. 116, No. 2, February 1968, pp. 14–17.

[27] Hoskins, K. C. Liming Down Under. Limestone, v. 5, No. 15, Spring 1968, pp. 22–23, 49–51.

[28] Dunn, James E. The Place or Point and Conditions of Acceptance of Construction Aggregates. Pit and Quarry, v. 60, No. 11, May 1968, pp. 96–98, 104.

[29] Work cited in footnote 24, pp. 92–95.

Potential demand for road materials was forecast, based on proposed new highway and turnpike projects. Another 2,500 miles of toll-highways are proposed, inclusive of tunnels, bridges, and toll facilities.[31] Traffic, and consequent demand for road materials and aggregates, is anticipated to double in most urban areas by 1985.

PRICES

Quotations in the Engineering News-Record for 1½ inch crushed stone in 1968 ranged from $5.50 per ton in Minneapolis to $1.55 per ton in Birmingham. The average price reported for 18 major cities was $2.68 per ton. Prices for ¾-inch crushed stone ranged from $5.50 per ton in Minneapolis to $1.60 per ton in Birmingham and St. Louis, and averaged $2.75 per ton for 19 cities.

Typical price ranges for industrial fillers and extenders per ton, as quoted in the American Paint Journal, were as follows:

Oystershell, powdered		$38.00
Oystershell, 20 mesh		$20.00
Silica, amorphous, 325 mesh	$28.00–	$55.10
Silica, amorphous, ultra-fine-ground		$65.00
Silica, crystalline	$20.50–	$45.40
Whiting precipitated, surface treated		$48.00
Whiting, dry ground, 325 mesh	$14.00–	$19.00
Whiting, precipitated, U.S.P	$50.00–	$117.00
Whiting, precipitated, technical	$33.00–	$44.00
Whiting, natural water ground	$37.00	

FOREIGN TRADE

In 1968 Canada received 85 percent of U.S. exports of crushed stone, and the Bahamas 8 percent. Limestone flux and calcareous stone for cement and lime manufacture accounted for 77 percent of export use.

Canada was the main source of imports of crushed stone, 97 percent; and the Bahamas furnished 2 percent. Principal items were limestone chips and spalls, 55 percent; stone crushed or ground, 43 percent; and marble, breccia, and onyx chips, 2 percent.

WORLD REVIEW

Canada.—Industrial Minerals of Canada, Ltd., announced plans for a silica quarry and crushing plant at Killarney, Ontario, and a $1.5 million processing plant in Midland, Ontario. The company also operates a nepheline syenite mine at Nephton, Ontario, and silica mines at St. Canut and St. Donat, Quebec.

South Africa, Republic of.—The largest road construction contract ever tendered was awarded for the Pretoria By-Pass and Transvaal carriageway, requiring over 350,000 cubic yards of crushed stone. Northern Lime Co. is the largest supplier of lime and limestone in the country, quarrying 3½ million tons of crushed stone annually at Silver Streams and Buxton.[32] Growth of the cement industry has established limestone quarrying as a major industry. Pretoria Portland Cement Co. produces 2 million tons of limestone annually.[33]

Upper Volta.—Two deposits of limestone, containing an estimated 30 million tons, were discovered at Tin Hassan. A United Nations survey team reported that local consumption would justify a 100,000-ton-per-year cement plant at nearby Tambao.

TECHNOLOGY

The Mining Research Division of the Bureau of Mines continued studies on the technology of crushed stone quarrying and related topics. Results of basic research on the strength of rock as it pertains to blasting or crushing of granite, sandstone, marble, and limestone were published.[34] Rock mechanics experiments on underground quarrying supports enabled development of design criterion for concrete support joints. Complete predesign of underground openings using concrete sets may become possible, as quarry operators turn to underground methods as an important answer to growing surface mining conflicts and the undesirable environmental or unsightly problems resulting from continuous surface quarrying.[35]

---

[30] Cosgrove, George V. Orange, Oyster, and Clay. Rock Prod., v. 71, No. 3, March 1968, pp. 56–59.

[31] Wolff, Jerome B. A New Turnpike Era? Roads And Streets, v. 111, No. 7, July 1968, pp. 51–52.

[32] South African Engineering and Mining Journal. Northern Lime Still Growing. V. 79, No. 3925, Apr. 26, 1968, p. 1017.

[33] South African Mining and Engineering Journal. Winning of Limestone for Cement Manufacture. V. 79, No. 3925, Apr. 26, 1968, pp. 1011–1015.

[34] Hoskins, John R., and Frank G. Horino. Effect of End Conditions on Determining Compressive Strength of Rock Samples. BuMines Rept. of Inv. 7171, Aug. 1968, 22 pp.

Costs and operating efficiency of the front-end loader were analyzed, based on data from the Power Crane and Shovel Association; sand and gravel, blasted rock, or crushed stone all came within the digging range of the front-end loader. Operating costs of $35 per hour compare with those using a power shovel.[36]

The 1,500-ton-per-hour crushing plant at the Yuba River Dam Project in California was the subject of an article. A total of 7 million tons of diabase, described as the "hardest rock in the world," will be required for aggregate.[37] The Dworshak Dam project in Idaho will require 12 million cubic yards of granite-gneiss for aggregate. Plans for a quarry atop a mountain, and a crushing plant within the mountain, will enable low cost of aggregate production in steep terrain; scarred land will be landscaped.[38]

---

[35] Dorman, K. R., M. E. Road, and M. O. Serbousek. Three-Piece Concrete Sets for Small Openings: A Progress Report. BuMines Rept. of Inv. 7114, April 1968, 51 pp.

[36] Gillespie, R. W. Another Look at How To Load Rock. Rock Prod., v. 71, No. 12 December 1968, pp. 67–69.

[37] Bergstrom, John H. Crushing "The Hardest Rock in the World". Rock Prod., v. 71, No. 12, December 1968, pp. 70–74.

[38] Etheridge, David C. Dworshak Dam: Aggregate Produced Inside Mountain. Construction Methods and Equipment, v. 50, No. 5, May 1968, 54–59.

Table 2.—Stone shipped or used by producers in the United States, by States

(Thousand short tons and thousand dollars)

State	1967		1968	
	Quantity	Value	Quantity	Value
Alabama	18,371	$33,346	20,643	$33,847
Alaska	W	W	W	W
Arizona	1,910	3,491	3,293	6,239
Arkansas	17,454	23,236	16,322	22,256
California	37,186	55,263	36,125	52,671
Colorado	2,992	5,485	2,471	5,201
Connecticut	5,097	10,141	6,383	12,729
Delaware	210	525	200	500
Florida	33,971	38,723	[1] 36,692	[1] 46,563
Georgia	23,418	49,953	26,903	56,177
Hawaii	4,100	7,207	5,211	11,273
Idaho	1,986	4,833	2,195	5,209
Illinois	48,458	66,757	55,858	80,188
Indiana	26,977	46,725	26,307	46,790
Iowa	26,133	37,912	26,150	40,397
Kansas	13,551	17,806	14,402	20,714
Kentucky	24,812	35,481	30,105	43,266
Louisiana	7,599	11,174	9,387	11,785
Maine [1]	1,159	2,999	1,187	3,205
Maryland	14,479	28,581	13,344	26,606
Massachusetts	6,203	17,724	6,917	19,501
Michigan	36,432	39,910	37,279	41,092
Minnesota	4,160	11,442	4,427	13,045
Mississippi	1,879	2,055	747	833
Missouri	36,585	53,953	38,763	58,522
Montana	4,782	6,037	3,314	4,878
Nebraska	4,846	7,483	4,416	7,435
Nevada	1,375	2,145	1,325	2,041
New Hampshire	473	2,887	383	3,377
New Jersey	12,611	28,253	13,151	30,343
New Mexico	1,391	2,403	2,226	3,527
New York	33,389	56,615	35,441	63,510
North Carolina	24,507	41,488	24,543	42,429
North Dakota	596	1,092	165	326
Ohio	45,458	72,534	[1] 48,054	[1] 78,772
Oklahoma	16,355	18,932	17,290	21,950
Oregon	13,201	20,256	14,312	21,168
Pennsylvania	60,155	103,157	62,812	108,151
Rhode Island	481	1,618	W	W
South Carolina	8,310	12,366	8,942	13,717
South Dakota	1,866	9,694	1,860	9,687
Tennessee [1]	31,463	41,958	32,083	43,854
Texas	49,424	61,577	48,480	58,006
Utah	1,831	4,108	1,953	4,312
Vermont	2,761	20,520	2,536	21,401
Virginia	31,324	52,470	31,217	53,533
Washington	14,454	19,099	14,331	16,690
West Virginia [1]	9,445	16,447	9,011	16,789
Wisconsin	17,122	24,863	17,000	25,223
Wyoming	1,246	2,375	1,434	2,754
Undistributed	1,602	5,144	1,811	5,272
Total [2]	785,592	1,240,244	819,403	1,317,753
Pacific Island Possessions	570	1,020	653	1,209
Panama Canal Zone	100	245	106	290
Puerto Rico	7,269	12,795	7,367	13,580
Virgin Islands	183	851	366	1,555

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] To avoid disclosing individual company data, certain State totals are incomplete, the portion not included being combined with "Undistributed." This class of stone omitted from such State totals is noted in the State tables in the Summary chapter of this volume.

[2] Data may not add to totals shown because of independent rounding.

Table 3.—Stone shipped or used by producers in the United States, by kind

(Thousand short tons and thousand dollars)

Year	Granite		Traprock [1]		Marble		Limestone dolomite		Shell	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1964	56,331	$114,465	66,090	$108,929	2,093	$36,693	511,026	$713,675	19,493	$30,157
1965	60,028	121,147	75,529	121,278	2,172	38,662	554,936	765,927	21,560	34,314
1966	65,888	128,558	88,623	147,594	2,244	36,203	569,577	794,279	21,662	32,783
1967	63,073	133,664	68,483	116,913	2,232	35,245	569,463	799,687	22,026	33,334
1968	70,506	148,333	73,117	125,476	2,559	32,372	603,545	873,477	20,268	28,563

Year	Calcareous marl		Sandstone quartzite		Slate		Other stone [2]		Total [3]	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1964	1,043	899	28,169	62,087	1,303	13,695	40,035	53,964	725,583	1,134,564
1965	1,291	1,125	29,097	61,710	1,263	13,697	34,366	45,971	780,242	1,203,831
1966	1,358	1,195	27,493	57,037	1,356	13,680	35,173	49,386	813,374	1,260,715
1967	1,227	1,084	27,249	60,494	1,260	14,615	30,580	45,208	785,592	1,240,244
1968	1,211	1,166	27,010	63,416	1,273	14,412	19,914	30,539	819,403	1,317,753

---

[1] Includes gabbro, basalt, diabase, etc.

[2] Includes mica schist, conglomerate, argillite, various light-colored volcanic rocks, serpentine not used as marble, soapstone sold as dimension stone, etc.

[3] Data may not add to total shown because of independent rounding.

Table 4.—Dimension stone shipped or used by producers in the United States, in 1968, by use and kind of stone

(Thousands)

Use and kind of stone	1967			1968		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
GRANITE						
Rough:						
Architectural	39	462	$1,594	69	811	$2,300
Construction [1]	133	1,079	974	122	1,491	1,036
Monumental	165	2,036	9,271	190	2,194	11,425
Dressed:						
Cut	14	169	3,916	46	555	10,442
Sawed	45	552	6,334	(2)	(2)	W
House stone veneer	7	83	1,666	5	61	331
Walls, foundations, bridges [3]	--------	--------	--------	16	200	1,251
Monumental [4]	55	661	10,144	52	579	11,077
Curbing	166	2,019	4,913	168	2,026	5,091
Other rough and dressed stone [5]	6	38	188	7	103	143
Total [6]	630	7,099	39,000	676	8,021	43,096
LIMESTONE AND DOLOMITE						
Rough:						
Architectural	190	2,602	3,688	245	2,823	4,130
Construction	89	31	801	63	765	584
Other rough stone [3]	--------	--------	--------	8	109	58
Dressed:						
Cut	69	904	6,006	90	1,153	5,678
Sawed	88	1,207	3,275	76	963	2,717
House stone veneer	99	1,300	2,634	96	1,246	2,823
Walls, foundations, bridges [3]	--------	--------	--------	8	109	139
Flagging [7]	26	335	147	15	184	143
Total [6]	561	6,380	16,552	602	7,352	16,273
MARBLE						
Rough:						
Architectural	7	81	259	15	164	1,117
Construction [1]	8	94	309	6	256	116
Other rough stone [3]	--------	--------	--------	5	56	14
Dressed:						
Cut	30	353	10,011	28	334	7,465
Sawed	11	126	1,507	8	94	1,332
House stone veneer [3]	--------	--------	--------	13	150	1,639
Walls, foundations, bridges [3]	--------	--------	--------	[8] 5	[8] 64	[8] 365
Monumental	19	221	4,000	8	96	2,118
Total [6]	74	875	16,086	89	1,214	14,166
SANDSTONE AND QUARTZITE						
Rough:						
Architectural	37	493	716	35	477	583
Construction	108	164	1,483	69	834	961
Other rough stone [3]	--------	--------	--------	3	32	34
Dressed:						
Cut	26	332	1,733	88	1,234	3,733
Sawed [9]	118	1,627	4,374	42	562	2,103
House stone veneer [3]	--------	--------	--------	30	390	762
Flagging [10]	57	690	2,036	43	507	1,975
Other uses not listed [11]	--------	--------	--------	2	25	882
Total [6]	346	3,306	10,342	312	4,061	11,033
SLATE [12]						
Roofing slate	21	[13] 56	2,202	19	[13] 48	2,006
Millstock:						
Electrical	21	2,318	2,866	17	2,309	2,504
Blackboards, etc	2	659	638	2	575	553
Billiard table tops	2	225	296	W	W	W
Total [6]	24	3,201	3,801	19	2,884	3,057
Flagstones [14]	44	7,679	1,293	43	7,489	1,221
Miscellaneous uses [15]	64	--------	2,309	73	258	3,008
Total [6]	154	--------	9,605	154	10,679	9,292

See footnotes at end of table.

Table 4.—Dimension stone shipped or used by producers in the United States, in 1968, by use and kind of stone—Continued

(Thousands)

Use and kind of stone	1967			1968		
	Short tons	Cubic feet	Value	Short tons	Cubic feet	Value
OTHER STONE [16]						
Rough:						
Construction [17]	189	1,882	3,191	1,596	18,796	4,903
Dressed:						
Flagging	5	21	84	6	65	107
Other uses not listed [18]	(2)	(2)	(2)	4	51	50
Total [6]	194	1,903	3,275	1,606	18,912	5,061
TOTAL STONE						
Rough:						
Architectural	273	3,640	6,257	376	4,441	8,348
Construction [1]	573	3,236	6,908	1,846	22,016	4,474
Monumental	165	2,036	9,271	190	2,198	11,442
Other rough stone [3]	--------	--------	--------	18	217	134
Dressed:						
Cut	139	1,758	21,666	262	3,391	30,599
Sawed	270	3,530	15,952	130	1,678	6,346
House stone veneer	106	1,388	4,300	145	1,861	5,581
Walls, foundations, bridges [3]	--------	--------	--------	29	364	1,474
Roofing (slate)	21	--------	2,202	19	--------	2,006
Millstock (slate)	24	--------	3,801	19	--------	3,057
Monumental [4]	73	884	14,145	61	680	13,318
Curbing	167	2,037	4,956	170	2,049	5,178
Flagging [12]	130	--------	3,532	108	1,396	3,452
Miscellaneous use (slate)	64	--------	2,309	73	--------	3,008
Other dressed stone [19]	6	35	173	5	49	129
Uses not listed or unspecified [3]	--------	--------	--------	6	84	1,107
Total [6]	2,011	--------	95,472	3,457	40,424	99,648

W Withheld to avoid disclosing company confidential data; included with house stone veneer.

[1] Includes irregular shaped stone and rubble.

[2] Less than ½ unit. Included with house stone veneer.

[3] Comparable data not available for 1967.

[4] Includes stone for precision plates.

[5] Includes paving blocks, refractory blocks and minor amount of flagging. 1968 data includes unspecified.

[6] Data may not add to totals shown due to independent rounding.

[7] 1967 data included stone for curbing.

[8] Includes curbing, flagging, and uses not listed or unspecified.

[9] Includes stone for refractory blocks.

[10] Includes stone for curbing.

[11] Includes stone for monumental purposes.

[12] Thousand square feet.

[13] Thousand squares.

[14] Includes slate used for walkways and stepping stones.

[15] Includes slate for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims.

[16] Produced by the following States in 1968 in order of value of output and with number of quarries: California (35); Hawaii (4); Virginia (9); Maryland (3); Pennsylvania (4); New Mexico (1); Arizona (1); New Jersey (1); Oregon (2); Washington (2); Nevada (1); and Montana (1).

[17] 1967 data includes rough and cut stone for refractory use. 1968 data includes stone used for architectural work, cut and sawed stone.

[18] Includes house stone veneer, walls, foundations, bridges, etc.

[19] Includes paving blocks, refractory blocks and slate used for aquarium bottoms, buildings, fireplaces, flooring, headstones, shims and unspecified uses.

Table 5.—Granite (dimension stone) shipped or used by producers in the United States in 1968, by States

State	Active quarries	Short tons	Value (thousands)	State	Active quarries	Short tons	Value (thousands)
California	9	6,857	$532	Oklahoma	9	8,985	$971
Colorado	3	1,174	113	South Carolina	3	13,936	580
Connecticut	4	3,290	69	South Dakota	7	38,422	6,519
Georgia	30	163,104	6,029	Wisconsin	11	9,535	2,291
Maine	7	15,044	704	Other States [1]	35	358,688	18,147
Minnesota	16	22,527	4,844				
New Mexico	1	144	3	Total [2]	145	675,615	43,096
North Carolina	10	33,909	2,293	Puerto Rico	6	16,300	50

[1] Includes quarries in Massachusetts (9), Missouri (1), New York (4), Pennsylvania (3), New Hampshire (2), Rhode Island (2), Texas (4), Vermont (7), and Washington (3).

[2] Data may not add to totals shown because of independent rounding.

Table 6.—Limestone and dolomite (dimension stone) shipped or used by producers in the United States in 1968, by States

State	Active quarries	Short tons	Value (thousands)	State	Active quarries	Short tons	Value (thousands)
California	3	775	$10	New Mexico	1	400	W
Illinois	3	9,248	102	Oklahoma	3	1,546	$22
Indiana	31	387,946	10,438	Washington	1	672	11
Iowa	3	11,200	239	Wisconsin	34	76,282	1,501
Kansas	8	10,358	532	Other States [1]	18	45,413	1,272
Michigan	3	2,680	51				
Minnesota	6	23,051	1,957	Total [2]	121	602,228	16,273
Missouri	4	27,799	112	Pacific Island Possessions	1	84,000	120
Nebraska	3	4,858	27	Puerto Rico	11	101,450	293

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Includes quarries in Alabama (2), Colorado (2), Florida (1), New York (2), Ohio (2), Rhode Island (1), South Dakota (1), Texas (5), Utah (1), and Virginia (1).

[2] Data may not add to totals shown because of independent rounding.

Table 7.—Sandstone and quartzite (dimension stone) shipped or used by producers in the United States in 1968, by States

State	Active quarries	Short tons	Value (thousands)	State	Active quarries	Short tons	Value (thousands)
Arkansas	4	11,646	291	New York	12	36,709	1,921
California	6	1,629	19	Ohio	19	114,693	4,999
Connecticut	3	6,000	44	Pennsylvania	31	65,696	1,399
Indiana	5	9,787	287	Wisconsin	8	2,348	52
Kansas	1	138	4	Wyoming	2	1,244	24
Maryland	4	10,714	198	Other States [1]	79	49,656	1,777
Michigan	1	1,500	15				
Montana	1	20	1	Total	183	311,970	11,033
New Mexico	7	190	2				

[1] Includes quarries in Arizona (18), Colorado (26), Georgia (4), Massachusetts (2), Minnesota (1), Missouri (1), Nevada (1), New Jersey (2), North Carolina (1), Oregon (1), Tennessee (8), Texas (1), Utah (7), Virginia (3), Washington (2), and West Virginia (1).

Table 8.—Crushed and broken stone shipped or used by producers in the United States, in 1968, by use and kind of stone

(Thousand short tons and thousand dollars)

Use and kind of stone	1967		1968	
	Quantity	Value	Quantity	Value
CALCAREOUS MARL [1]				
Agricultural purposes [2]	191	$143	186	$150
Cement manufacture	1,036	940	1,025	1,016
Total	1,227	1,083	1,211	1,166
GRANITE				
Agricultural purposes [3]	39	398	105	994
Concrete aggregate (coarse)	[4] 54,021	80,593	8,151	12,358
Bituminous aggregate			7,940	12,798
Macadam aggregates			2,171	3,087
Dense graded road base stone			37,756	56,334
Surface treatment aggregates			4,875	6,224
Riprap and jetty stone	2,816	6,075	2,351	4,933
Railroad ballast	2,612	3,438	3,244	4,322
Filter stone	---------	---------	94	159
Manufactured fine aggregate (stone sand)	[5] 1,314	1,666	1,153	1,120
Other uses [6]	758	1,673	1,825	2,647
Uses not listed or unspecified	883	823	164	266
Total	62,443	94,664	69,830	105,236
LIMESTONE AND DOLOMITE				
Agricultural purposes [3]	30,153	56,468	38,369	68,988
Concrete aggregate (coarse)	[4] 356,534	468,351	102,649	146,041
Bituminous aggregate			43,887	65,838
Macadam aggregates			29,999	42,487
Dense graded road base stone			143,016	186,381
Surface treatment aggregates			47,082	66,828
Riprap and jetty stone	13,570	16,464	12,984	16,799
Railroad ballast	5,634	6,729	5,721	7,374
Filter stone	84	194	486	918
Manufactured fine aggregate (stone sand)	1,795	3,198	3,208	5,204
Terrazzo and exposed aggregate	13	119	139	825
Cement manufacture	91,456	96,878	97,773	104,682
Lime manufacture	25,505	44,672	27,473	50,460
Dead-burned dolomite	2,820	4,367	3,055	4,928
Flux	28,781	43,858	28,268	43,329
Refractory	463	3,415	473	1,270
Chemical stone for alkali works	2,026	2,150	2,520	3,705
Special uses and products [7]	3,706	19,300	3,531	20,092
Other uses [6]	4,408	13,020	6,800	11,569
Uses not listed or unspecified	1,954	3,952	5,563	9,496
Total	568,902	783,135	602,943	857,204
MARBLE				
Agricultural purposes [3]	(8)	(8)	424	1,313
Concrete aggregate (coarse)	[4] W	W	[9] 795	[9] 1,904
Macadam aggregates				
Dense graded road base stone				
Surface treatment aggregates				
Terrazzo and exposed aggregate	309	4,527	201	3,349
Cement manufacture	(8)	(8)	[10] 31	[10] 171
Special uses and products [7]	(8)	(8)	951	10,641
Other uses [6]	1,779	13,800	41	592
Uses not listed or unspecified	70	832	27	236
Total	2,158	19,159	2,470	18,206
SANDSTONE, QUARTZ AND QUARTZITE [11]				
Concrete aggregate (coarse)	[4] 17,915	26,110	4,110	7,605
Bituminous aggregate			2,859	5,358
Macadam aggregates			961	1,007
Dense graded road base stone			9,497	14,029
Surface treatment aggregates			1,042	2,062
Riprap and jetty stone	3,661	5,701	2,856	4,227
Railroad ballast	1,410	1,820	1,269	1,782
Filter stone	33	86	140	272
Manufactured fine aggregate (stone sand)	304	432	340	698
Terrazzo and exposed aggregate	17	662	56	1,095
Cement manufacture	460	689	672	1,081
Ferrosilicon	108	700	303	1,620
Flux	636	2,651	818	2,962
Refractory	354	4,924	632	5,311
Special uses and products [7]	92	552	59	366
Other uses [6]	1,050	3,911	[8] 831	[8] 2,196

See footnotes at end of table.

Table 8.—Crushed and broken stone shipped or used by producers in the United States, in 1968, by use and kind of stone—Continued

(Thousand short tons and thousand dollars)

Use and kind of stone	1967		1968	
	Quantity	Value	Quantity	Value
SANDSTONE, QUARTZ AND QUARTZITE—Continued				
Uses not listed or unspecified	863	1,914	253	716
Total	26,903	50,152	26,968	52,382
SHELL				
Agricultural purposes	253	2,394	236	2,378
Concrete aggregate (coarse)	[4] 15,143	20,832	6,830	8,313
Macadam aggregates			---	---
Dense graded road base stone			5,835	7,592
Cement manufacture	5,311	7,909	[9] 5,520	[9] 7,807
Lime manufacture	1,090	1,475	---	---
Other uses not listed [12]	229	723	1,847	2,474
Total	22,026	33,334	20,268	28,563
TRAPROCK				
Concrete aggregate (coarse)	[4] 57,977	97,202	11,447	22,480
Bituminous aggregate			10,651	20,240
Macadam aggregates			2,869	5,108
Dense graded road base stone			20,467	35,481
Surface treatment aggregates			7,755	12,512
Riprap and jetty stone	3,695	7,639	2,552	5,655
Railroad ballast	1,500	2,293	1,400	2,212
Filter stone	---	---	68	114
Manufactured fine aggregate (stone sand)	62	142	151	374
Special uses and products [7]	[13] 8	13	154	323
Other uses [6]	4,034	7,265	6,019	8,442
Uses not listed of unspecified	1,153	1,747	9,566	11,808
Total [14]	68,430	116,301	73,099	124,749
OTHER STONE				
Concrete aggregate (coarse)	[4] 19,224	25,684	809	1,575
Bituminous aggregate			2,564	4,329
Macadam aggregates			264	365
Dense graded road base stone			7,669	9,370
Surface treatment aggregates			606	832
Riprap and jetty stone	6,895	9,961	1,665	2,980
Railroad ballast	2,330	1,997	1,221	869
Other uses [6]	[14] 940	[14] 3,491	2,503	3,981
Uses not listed or unspecified	998	800	1,008	1,176
Total	30,387	41,933	18,308	25,477
TOTAL STONE				
Agricultural purposes	30,722	59,762	39,330	73,851
Concrete aggregate (coarse)	521,367	720,323	134,713	199,848
Bituminous aggregate			67,901	108,552
Macadam aggregates			36,264	52,054
Dense graded road base stone			224,309	309,594
Surface treatment aggregates			61,369	88,480
Riprap and jetty stone	30,637	45,840	23,154	35,619
Railroad ballast	13,486	16,277	12,855	16,559
Filter stone	136	413	1,318	2,191
Manufactured fine aggregate (stone sand)	3,532	5,433	4,958	7,587
Terrazzo and exposed aggregate	343	5,376	406	5,346
Cement manufacture	98,263	106,416	104,093	113,518
Lime manufacture	26,595	46,148	28,468	51,677
Dead-burned dolomite	2,820	4,367	3,055	4,923
Ferrosilicon	108	700	303	1,620
Flux	29,420	46,512	29,087	46,292
Refractory	819	8,341	1,105	6,581
Chemical stone for alkali works	2,026	2,150	2,890	4,215
Special uses and products [7]	4,556	28,806	4,951	32,008
Other uses [6]	12,732	37,651	[15] 18,835	[15] 33,887
Uses not listed or unspecified	6,018	10,256	16,582	23,703
Total	783,581	1,144,772	815,946	1,218,105

See footnotes at end of table.

FOOTNOTES PERTAINING TO TABLE 8

W Withheld to avoid disclosing company confidential data.

[1] Produced by the following states in 1968, in order or tonnage: Miss., Va., Tex., Mich., Ind., Wisc., Minn. and Nev.

[2] Includes marl used in agricultural limestone, other soil conditioners and nutrients and a small amount of marl used in mineral fillers, or extenders.

[3] Includes agricultural limestone, other soil conditioners and nutrients, and poultry grit and mineral food.

[4] Comparable data not available in 1967.

[5] Includes small amount of terrazzo and exposed aggregate.

[6] Includes some stone used for fill, roofing aggregates, glass, dam construction and other uses in smaller quantities.

[7] Includes stone used for mineral fillers, extenders, and whiting and smaller quantities used for mine dusting and abrasives.

[8] 1967 data included with "other uses."

[9] 1968 data combined to avoid disclosing company confidential data.

[10] 1968 data includes stone sand, and a small amount of riprap and jetty stone.

[11] Includes ground sandstone, quartz and quartzite, Friable sandstone is reported in the chapter on sand and gravel.

[12] 1967 data includes alkali, asphalt filler, other filler, mineral food, and unspecified uses. 1968 data includes stone for alkali works, asphalt filler, filter stone, riprap and jetty stone.

[13] Includes small amount of stone used for agricultural purposes. 1968 data also includes stone used for cement manufacture.

[14] Includes filter stone, stone sand, terrazzo, flux and stone used in cement manufacture.

[15] Includes slate used for granules, flour, refuse or waste, expanded slate and other uses.

Table 9.—Number and production of crushed-stone plants in the United States, by size of operation[1]

Annual production (short tons)	1967			1968		
	Number of plants	Production		Number of plants	Production	
		Thousand short tons	Percent of total		Thousand short tons	Percent of total
Less than 25,000	1,013	8,352	1.2	1,582	14,087	1.7
25,000 to 49,000	363	13,099	1.8	570	20,206	2.5
50,000 to 74,000	226	14,058	1.9	318	19,692	2.4
75,000 to 99,999	218	18,773	2.6	270	23,198	2.9
100,000 to 199,999	508	71,471	9.9	581	82,357	10.1
200,000 to 299,999	266	65,178	9.1	311	76,643	9.4
300,000 to 399,999	216	75,117	10.4	206	69,915	8.6
400,000 to 499,999	131	58,021	8.1	144	63,697	7.8
500,000 to 599,999	98	53,891	7.4	81	43,736	5.4
600,000 to 699,999	69	44,678	6.2	69	44,787	5.5
700,000 to 799,999	60	44,589	6.2	63	46,822	5.7
800,000 to 899,999	41	34,543	4.8	43	38,024	4.7
900,000 and over	134	218,852	30.4	169	271,713	33.3
Total[2]	3,338	720,616	100.0	4,407	814,827	100.0

[1] Does not include State operations.

[2] Data may not add to totals shown because of independent rounding.

Table 10.—Crushed stone shipped or used in the United States, by methods of transportation

Method of transportation	1967		1968	
	Thousand short tons	Percent of total	Thousand short tons	Percent of total
Truck	578,293	74	565,764	69
Rail	89,124	11	89,315	11
Waterway	68,029	9	72,930	9
Other[1]	---------	-------	45,527	6
Unspecified	48,135	6	42,410	5
Total	783,581	100	815,946	100

[1] Comparable data not available in previous years.

Table 11.—Granite (crushed and broken stone) shipped or used by producers in the United States in 1968, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arizona	18	$24	New Hampshire	54	$48
California	4,045	5,765	New Jersey	1,226	2,401
Colorado	200	857	North Carolina	16,486	26,622
Delaware	200	500	South Carolina	6,978	10,287
Georgia	19,423	28,095	Virginia	9,377	14,554
Massachusetts	1,158	1,944	Wisconsin	1,342	324
Michigan	2	60	Wyoming	521	782
Minnesota	422	679	Other States [1]	8,171	12,645
Montana	80	54			
Nevada	176	145	Total [2]	69,830	105,286
			Puerto Rico	254	542

[1] Includes quarries in Alaska, Arkansas, Connecticut, Idaho, Maine, Maryland, Missouri, New York, Pennsylvania, Texas, Vermont, and Washington.

[2] Data may not add to totals shown because of independent rounding.

Table 12.—Traprock (crushed and broken stone) shipped or used by producers in the United States in 1968, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
California	1,471	$1,840	Oregon	18,517	$19,186
Connecticut	5,806	10,201	Utah	(1)	(1)
Hawaii	3,781	8,605	Virginia	3,586	6,207
Idaho	657	968	Washington	12,671	12,950
Maryland	3,848	7,307	Wyoming	107	182
Massachusetts	4,005	7,577	Other States [2]	8,844	20,018
Michigan	21	33			
Minnesota	55	W	Total [3]	78,099	124,749
New Jersey	11,173	24,243	Panama Canal Zone	106	290
North Carolina	3,562	5,486	Virgin Islands	366	1,555

W Withheld to avoid disclosing individual company confidential data; included with "Other States."

[1] Less than ½ unit.

[2] Includes quarries in Alaska, Arizona, Missouri, Montana, New Mexico, New York, Pennsylvania, Texas, Vermont and Wisconsin.

[3] Data may not add to totals shown because of independent rounding.

Table 13.—Limestone and dolomite (crushed and broken stone) shipped or used by producers in the United States in 1968, by States and uses

(Thousand short tons and thousand dollars)

State	Agriculture [1]		Aggregates		Riprap		Railroad ballast		Fluxing stone		Miscellaneous and undistributed		Total	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Alabama	986	$1,603	10,629	$13,233	385	$573	89	$114	724	$1,176	5,647	$6,393	18,460	$23,092
Arizona	-------	-------	W	W	-------	-------	-------	-------	W	W	2,761	4,663	2,761	4,663
Arkansas	579	1,147	1,571	1,819	W	W	-------	-------	W	W	2,804	3,267	4,954	6,234
California	W	W	W	W	27	69	-------	-------	565	916	15,907	22,897	16,499	23,882
Colorado	-------	-------	273	505	W	W	-------	-------	W	W	1,538	3,181	1,812	3,686
Connecticut	84	351	W	W	W	W	-------	-------	W	W	146	784	230	1,134
Florida	1,004	3,416	28,072	34,725	-------	-------	70	99	-------	-------	6,402	6,372	35,548	44,612
Georgia	W	W	3,022	4,576	-------	-------	-------	-------	W	W	1,565	2,306	4,587	6,881
Hawaii	27	473	451	887	-------	-------	-------	-------	-------	-------	451	463	930	1,823
Idaho	-------	-------	-------	-------	-------	-------	-------	-------	-------	-------	W	W	W	W
Illinois	4,920	8,175	44,236	62,980	673	1,090	204	255	936	1,320	4,878	6,264	55,848	80,083
Indiana	2,178	3,613	19,261	26,508	937	2,203	440	584	35	51	3,017	3,072	25,867	36,031
Iowa	2,642	5,482	18,655	28,352	450	833	192	170	W	W	W	W	26,139	40,158
Kansas	780	1,281	8,871	12,803	369	381	W	W	-------	-------	3,526	4,270	13,547	18,735
Kentucky	290	3,436	23,341	33,550	2,605	3,002	W	W	W	W	1,843	2,775	29,979	42,762
Maine	W	W	W	W	-------	-------	30	52	-------	-------	817	1,428	848	1,480
Maryland	107	290	6,266	10,767	W	W	W	W	W	W	2,232	5,051	8,605	16,108
Massachusetts	186	715	W	W	-------	-------	-------	-------	W	W	486	2,741	672	3,456
Michigan	703	890	5,997	7,329	W	W	281	370	11,376	14,327	W	W	37,116	40,827
Minnesota	336	620	3,229	4,116	48	62	W	W	-------	-------	W	W	3,800	5,207
Mississippi	W	W	-------	-------	-------	-------	-------	-------	-------	-------	297	321	297	321
Missouri	4,354	7,112	20,888	28,033	3,208	2,909	134	182	17	108	9,270	15,643	371	53,987
Montana	-------	-------	-------	-------	W	W	W	W	W	W	1,363	1,856	1,363	1,856
Nebraska	W	W	1,913	2,949	1,237	1,773	W	W	-------	-------	W	W	4,411	7,408
Nevada	W	W	96	67	-------	-------	-------	-------	W	W	W	W	W	W
New Jersey	W	W	98	306	-------	-------	-------	-------	W	W	W	W	W	W
New Mexico	-------	-------	1,055	1,745	14	26	-------	-------	W	W	W	W	1,637	2,657
New York	357	1,043	22,054	41,461	167	337	488	832	W	W	9,134	9,336	32,200	53,009
North Carolina	4	5	W	W	W	W	W	W	-------	-------	W	W	W	W
Ohio	1,885	3,586	29,065	40,766	306	496	962	1,221	4,061	5,812	10,874	19,611	47,153	71,498
Oklahoma	5,934	6,361	6,449	8,083	265	349	W	W	-------	-------	2,354	3,769	15,002	18,563
Oregon	W	W	W	W	W	W	-------	-------	W	W	W	W	W	W
Pennsylvania	1,490	4,068	29,030	41,220	W	W	230	340	5,316	10,828	16,690	23,628	52,756	80,085
Rhode Island	W	W	-------	-------	-------	-------	-------	-------	W	W	W	W	W	W
South Carolina	W	W	W	W	-------	-------	-------	-------	W	W	1,950	2,900	1,950	2,900
South Dakota	36	W	524	760	W	W	W	W	-------	-------	522	934	1,082	1,694
Tennessee	2,508	3,569	23,813	30,659	233	169	W	W	W	W	5,485	7,664	32,040	42,060
Texas	941	1,036	25,790	26,347	327	395	636	601	1,025	1,157	8,987	10,940	37,706	40,476
Utah	W	W	96	208	1	1	-------	-------	W	W	1,719	3,607	1,817	3,816
Vermont	88	347	338	496	W	W	-------	-------	-------	-------	200	2,465	626	3,308
Virginia	1,196	2,160	9,702	13,517	14	18	381	426	W	W	5,287	9,098	16,579	25,220
Washington	W	W	-------	-------	-------	-------	-------	-------	W	W	958	1,516	958	1,516
West Virginia	127	311	2,641	4,479	W	W	588	739	W	W	4,593	8,748	7,949	14,277
Wisconsin	996	1,653	12,384	13,895	W	W	W	W	36	52	610	968	14,026	16,568

Wyoming	-------	-------	W	W	W	W	W	W	-------	-------	688	1,378	688	1,378
Total [2]	36,638	62,744	359,810	497,141	11,268	14,690	4,726	5,984	24,093	35,747	135,002	200,308	596,314	843,449
Undistributed	1,731	6,244	6,822	10,433	1,666	2,110	995	1,390	4,176	7,582	31,406	40,589	6,630	13,755
Pacific Island Possessions	-------	-------	502	W	8	10	-------	-------	-------	-------	59	W	569	1,809
Puerto Rico	43	127	2,685	7,076	-------	-------	-------	-------	-------	-------	2,891	2,205	5,619	9,408

W Withheld to avoid disclosing individual company confidential data; included with "Miscellaneous and Undistributed."

[1] Includes agricultural limestone, other soil conditioners and nutrients, and poultry grit and mineral food.

[2] Data may not add to total shown because of independent rounding.

Table 14.—Shell shipped or used by producers in the United States in 1968, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value
Florida	1,144	$1,951
Louisiana	9,387	11,784
Texas	7,851	10,785
Other States [1]	1,886	4,044
Total [2]	20,268	28,563

[1] Includes quarries in Alabama, California, Maryland, New Jersey, Pennsylvania, and Virginia.
[2] Data may not add to totals shown because of independent rounding.

Table 15.—Calcareous marl shipped or used by producers in the United States in 1968, by States

State	Short tons	Value
Indiana	35,828	$28,311
Michigan	134,394	105,939
Minnesota	3,850	2,625
Wisconsin	6,179	2,223
Other States [1]	1,030,764	1,027,015
Total	1,211,015	1,166,113

[1] Includes quarries in Mississippi, Nevada, Texas, and Virginia.

Table 16.—Sandstone quartz, and quartzite (crushed and broken stone) shipped or used by producers in the United States in 1968, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arkansas	6,459	$8,365	Oklahoma	1,083	$1,646
California	3,034	5,786	Oregon	198	534
Illinois	(1)	3	Pennsylvania	3,698	8,990
Indiana	6	6	South Dakota	676	1,402
Kansas	724	1,370	Texas	2,320	2,840
Kentucky	126	504	Vermont	612	1,282
Montana	219	503	Virginia	565	885
Nevada	101	71	Washington	201	1,090
New Mexico	189	W	West Virginia	1,063	2,512
New York	472	986	Other States [2]	4,166	11,326
Ohio	786	2,280			
			Total [3]	26,698	52,382

W Withheld to avoid disclosing individual company confidential data; included with "Other States".
[1] Less than ½ unit.
[2] Includes quarries in Alabama, Alaska, Arizona, Colorado, Connecticut, Georgia, Idaho, Maryland, Minnesota, Missouri, New Hampshire, North Carolina, Tennessee, Utah, Wisconsin, and Wyoming.
[3] Data may not add to totals shown because of independent rounding.

Table 17.—Miscellaneous varieties of stone (crushed and broken) shipped or used by producers in the United States in 1968, by States

(Thousand short tons and thousand dollars)

State	Quantity	Value	State	Quantity	Value
Arizona	44	$77	Oklahoma	1,193	$749
California	9,070	11,973	Oregon	190	174
Colorado	204	410	Pennsylvania	1,799	2,576
Hawaii	483	732	Washington	231	248
Idaho	5	66	Wyoming	101	164
Massachusetts	921	1,700	Other States [1]	[1] 2,543	4,226
Missouri	292	468			
Montana	1,065	1,589	Total [2]	18,308	25,477
North Dakota	165	326	Puerto Rico	1,272	2,963

[1] Includes quarries in Alaska, Kansas, Louisiana, Maine, Maryland, Nevada, New Hampshire, New Jersey, New Mexico, New York, South Dakota, Texas, Utah, Vermont, and Virginia.

[2] Data may not add to totals shown because of independent rounding.

Table 18.—U.S. exports of stone

(Thousands)

Year	Building and monumental stone			Crushed, ground, or broken				Other manufactures of stone (value)
	Dolomite		Other (value)	Limestone		Other		
	Short tons	Value		Short tons	Value	Short tons	Value	
1966	101	$1,692	$1,104	1,207	$3,500	276	$3,406	$1,432
1967	113	1,756	958	1,159	3,496	306	3,748	1,203
1968	102	1,518	849	1,297	3,294	292	3,278	1,030

Table 19.—U.S. imports for consumption of stone and whiting, by classes

Class	1967		1968	
	Quantity	Value (thousands)	Quantity	Value (thousands)
Granite:				
Monumental, paving and building stone:				
Rough..........cubic feet..	169,193	$1,001	252,023	$1,088
Dressed, manufactured..........do....	173,064	1,662	406,042	3,115
Not manufactured and not suitable for monumental, paving or building stone..........short tons..	269	11	788	18
Other, n.s.p.f..........	---------	71	---------	73
Total..........	---------	2,745	---------	4,294
Marble, breccia, and onyx:				
In block, rough or squared..........cubic feet..	53,668	360	33,537	283
Sawed or dressed over 2 inches thick..........do....	5,164	38	8,951	82
Slabs and paving tiles..........superficial feet..	6,025,706	5,139	8,395,719	6,706
All other manufactures..........	---------	3,776	---------	4,163
Total..........	---------	9,313	---------	11,234
Travertine stone:				
Rough, unmanufactured..........cubic feet..	45,463	138	43,793	129
Dressed, suitable for monumental, paving and building stone short tons..	34,537	1,035	32,926	1,404
Other, n.s.p.f..........	---------	77	---------	68
Total..........	---------	1,250	---------	1,601
Limestone:				
Monumental, paving, and building stone:				
Rough..........cubic feet..	1,378	3	4,636	8
Dressed, manufactured..........short tons..	4,502	72	6,809	35
Crude, not suitable for monumental, paving or building stone short tons..	41,600	121	20,911	68
Other, n.s.p.f..........	---------	49	---------	43
Total..........	---------	245	---------	154
Slate:				
Roofing..........square feet..	---------	------	2,826	1
Other, n.s.p.f..........	---------	2,333	---------	2,130
Total..........	---------	2,333	---------	2,131
Quartzite..........short tons..	4,213	260	7,147	273
Stone and articles of stone, n.s.p.f.:				
Statuary and sculptures..........	---------	266	---------	251
Stone, unmanufactured..........short tons..	7,561	107	40,765	198
Building stone, rough..........cubic feet..	5,517	9	3,471	6
Building stone, dressed..........short tons..	1,232	41	515	16
Other..........	---------	157	---------	210
Total..........	---------	580	---------	681
Stone, chips, spalls, crushed or ground:				
Marble, breccia and onyx chips..........short tons..	8,129	127	6,436	89
Limestone, chips and spalls, crushed or ground..........do....	[r] 1,205,166	1,529	1,677,410	2,075
Stone chips and spalls and stone crushed or ground, n.s.p.f short tons..	1,070,730	1,079	1,368,243	1,599
Slate chips and spalls and slate crushed and ground..........do....	---------	------	304	1
Total..........	[r] 2,284,025	2,735	3,052,393	3,764
Whiting:				
Whiting, dry, ground, or bolted..........short tons..	11,558	206	15,904	326
Chalk whiting, precipitated..........do....	2,113	156	2,339	170
Chalk whiting, putty..........do....	(1)	(1)	---------	------
Total..........	13,671	362	18,243	496
Grand total..........	---------	19,823	---------	24,628

[r] Revised.
[1] Less than ½ unit.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/88

Sulfur and Pyrites

By Donald E. Eilertsen [1]

U.S. output of native and other forms of sulfur broke all records while apparent consumption of all forms of sulfur was the third largest. Yearend stocks of Frasch sulfur were the largest since November 1966 and yearend stocks of recovered sulfur were the largest since January 1967.

Table 1.—Salient sulfur statistics

(Thousand long tons, sulfur content)

	1964	1965	1966	1967	1968
United States:					
Production (native)	5,228	6,116	7,002	7,014	7,460
All forms	7,093	8,212	9,155	9,136	9,817
Exports, sulfur	1,928	2,635	2,373	2,193	1,602
Imports, pyrites and sulfur	1,582	1,646	1,674	1,639	1,712
Stocks Dec. 31: Producer, Frasch and recovered sulfur	4,227	3,425	2,704	1,954	2,790
Consumption, apparent, all forms [1]	7,255	7,981	9,145	9,301	9,085
World: Production:					
Sulfur, elemental	13,916	15,286	16,442	17,597	18,604
Pyrites	9,200	9,560	9,627	9,923	9,905

[1] Measured by quantity sold, plus import, minus exports.

DOMESTIC PRODUCTION

Native Sulfur.—Frasch sulfur was produced at 20 mines in 1968. The producers and mines in Louisiana were Freeport Sulphur Co., at Caminada (new and offshore), Grand Isle (offshore), Garden Island Bay, Grand Ecaille, and Lake Pelto; Texas Gulf Sulphur Co., at Bully Camp; Jefferson Lake Sulphur Co., at Lake Hermitage; U.S. Oil of Louisiana, Ltd., at Chacahoula; and Union Texas Petroleum at Sulfur. The producers and mines in Texas were Texas Gulf Sulphur Co., at Fannett Dome, Spindletop Dome, Moss Bluff Dome, Gulf, and Boling Dome; Duval Corp. at Orchard Dome and Ft. Stockton; Jefferson Lake Sulphur Co., at Long Point Dome; Phelan Sulphur Co., at Nash Dome; Sinclair Oil Corp., at Fort Stockton; and Hooker Chemical Corp., at Bryan Mound.

The Duval Corp. drilled for elemental sulfur in Culberson County, Tex., and discovered deposits containing an estimated recoverable reserve of 57 million long tons of sulfur. Mine facilities were being designed to produce 2.5 million long tons of sulfur annually. The initial annual output will be 1.5 million tons and production is expected to start in August 1969.

Freeport Sulphur Co. publicly reported that it produced approximately 3.9 million tons of sulfur in 1968 and that its sales totaled about 3.8 million tons of which 75 percent was used domestically and 25 percent for exports.[2] Freeport Chemical Co., a new division of Freeport Sulphur Co., produced sulfuric acid and phosphoric acid at its new facility at Uncle Sam, La., on the Mississippi River between New Orleans and Baton Rouge. The sulfuric acid plant has an annual capacity of 1.68

---

[1] Physical scientist, Division of Mineral Studies.

[2] Freeport Sulphur Co. Annual Report. 1968, p. 6.

million tons, and the phosphoric acid plant 1.1 million tons of commercial 54-percent phosphoric acid containing 600,000 tons of P_2O_5. The company uses its own raw materials—sulfur from its nearby Frasch sulfur mines, and phosphate rock from Florida.

Jefferson Lake Sulphur Co., a subsidiary of Occidential Petroleum Corp., began sulfur production at its new Lake Hermitage mine in Louisiana. The parent firm also leased and explored promising prospects in western Texas and in Mexico for Frasch sulfur.

Texas Gulf Sulphur Co. (TGS) did some exploratory drilling for sulfur in Pecos County, Tex., and encouraging results led to further work. The company also drilled for sulfur in Culberson County, Tex., and in Eddy County, N. Mex. TGS's Frasch sulfur mine at Bully Camp, La., started operation. This mine, located about 40 miles southwest of New Orleans, reportedly will have a capacity of 300,000 long tons of sulfur annually.

California was the only producer of sulfur ore—the output (shipments) totaled 3,125 long tons valued at $46,000.

Table 2.—Production of sulfur and sulfur-containing raw materials by producers in the United States

(Long tons)

	1965		1966		1967		1968	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
Native sulfur or sulfur ore:								
Frasch-process mines	6,116,273	6,116,273	7,001,360	7,001,360	7,014,164	7,014,164	7,458,392	7,458,392
Other mines	2,592	133	557	143	568	284	3,125	1,563
Total	-----------	6,116,406	-----------	7,001,503	-----------	7,014,448	-----------	7,459,955
Recovered elemental sulfur	1,219,312	1,215,168	1,243,960	1,240,386	1,270,289	1,267,955	1,358,926	1,353,692
Pyrites	874,957	353,645	872,414	355,592	860,909	355,033	871,955	362,143
Byproduct sulfuric acid (basis 100 percent) produced at Cu, Zn, and Pb plants	1,188,314	388,484	1,297,184	424,075	1,114,881	364,477	1,315,251	429,982
Other byproduct sulfur materials [1]	162,668	138,660	161,962	133,859	157,262	134,198	247,297	210,780
Total	-----------	8,212,363	-----------	9,155,415	-----------	9,136,111	-----------	9,816,552

[1] Hydrogen sulfide and liquid sulfur dioxide. Does not include acid sludge converted sulfuric acid.

Table 3.—Sulfur produced and shipped from Frasch mines in the United States

(Thousand long tons and thousand dollars)

Year	Production			Shipments	
	Texas	Louisiana	Total [1]	Quantity	Approimate value
1964	2,489	2,739	5,228	6,036	$120,777
1965	2,534	3,582	6,116	7,251	164,654
1966	2,916	4,085	7,001	7,721	201,292
1967	2,956	4,059	7,014	7,682	251,670
1968	3,203	4,255	7,458	6,645	268,146

[1] Data may not add to totals shown because of independent rounding.

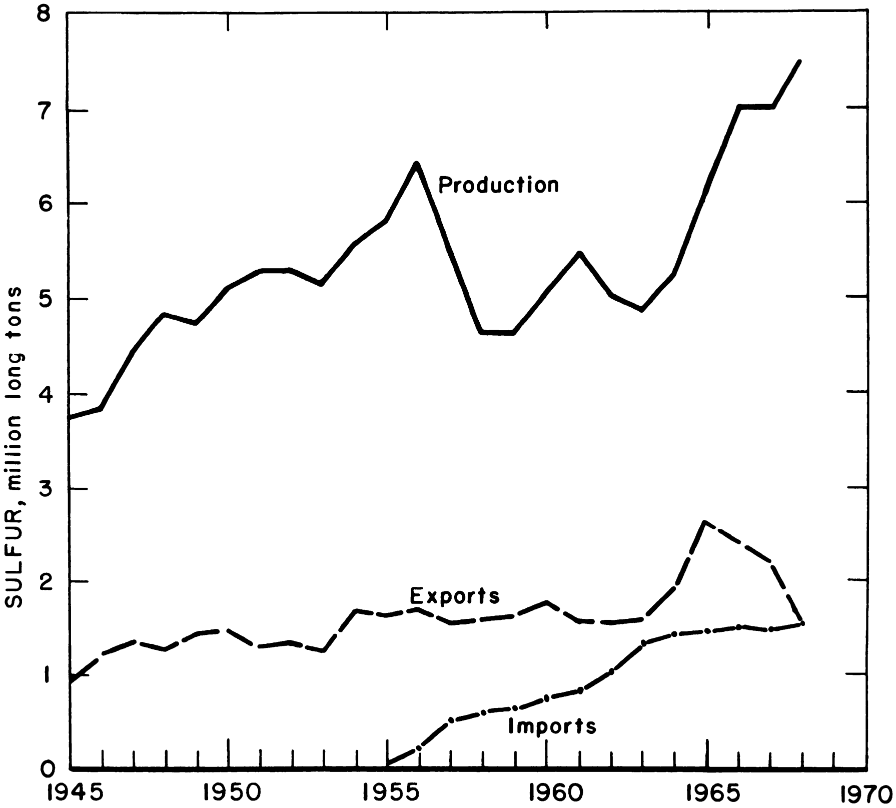

Figure 1.—Domestic native production, imports, and exports of native sulfur.

Table 4.—Sulfur ore (10 to 70 percent S) produced and shipped in the United States[1]

(Long tons)

Year	Production		Shipments		
	Gross weight	Sulfur content	Gross weight	Sulfur content	Value (thousands)
1964	794	158	794	158	$8
1965	2,592	133	2,852	288	11
1966	557	143	557	143	5
1967	568	284	568	284	3
1968	3,125	1,563	3,125	1,563	46

[1] California, Nevada, and Utah.

Recovered Sulfur.—Output of recovered sulfur broke all records while shipments were the second largest on record. Data on shipments of recovered sulfur and values are listed as follows:

State	Quantity (long tons)	Value (thousands)
Arkansas	26,215	$1,049
California	152,342	6,004
New Jersey	50,587	2,222
New Mexico	24,914	974
Texas	645,925	25,495
Wyoming	48,153	961
Other States [1]	325,054	11,984
Total	1,273,190	48,689

[1] Combined to avoid disclosing individual company confidential data; includes Colorado, Delaware, Illinois, Indiana, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Montana, North Dakota, Ohio, Oklahoma, Pennsylvania, and Virginia.

Phillips Petroleum Co. and Pan American Petroleum Corp. planned to recover sulfur from nonhydrocarbon gas analyzing nearly 78 percent hydrogen sulfide found at a depth of 20,000 feet, 40 miles north of Biloxi, Miss.[3]

Pyrites.—Producers of pyrites in Arizona, Colorado, Pennsylvania, South Carolina, Tennessee, and Utah sold or used approximately 872,000 long tons of pyrites containing an average of 41.53 percent sulfur in 1968. Tennessee accounted for the largest amount by far.

Byproduct Sulfur.—Thirteen States produced 1,473,081 short tons of byproduct sulfuric acid valued at $23,202,000 in 1968—Arizona, Tennessee, Utah and Washington from copper smelters; California from lead smelting; and Idaho, Illinois, Kansas, Montana, Ohio, Oklahoma, Pennsylvania, and Texas from zinc smelters and roasters.

Sulfuric acid output from copper and lead smelters totaled 483,108 short tons valued at $5,804,000, the largest output by far being from copper smelters. Zinc smelters and roasters produced 989,973 short tons of sulfuric acid valued at $17,398,000.

In addition to byproduct sulfuric acid 247,297 long tons of byproduct hydrogen sulfide and sulfur dioxide were produced, the largest output by far being hydrogen sulfide.

---

[3] Industrial Minerals (London). Unique Sulphur Project. No. 11, August 1968, p. 21.

Table 5.—Recovered sulfur produced and shipped in the United States

(Thousand long tons and thousand dollars)

Year	Production		Shipments		
	Gross weight	Sulfur content	Gross weight	Sulfur content	Value
1964	1,025	1,021	994	990	$21,088
1965	1,219	1,215	1,173	1,169	24,574
1966	1,244	1,240	1,265	1,261	30,166
1967	1,270	1,268	1,286	1,284	40,984
1968	1,359	1,354	1,278	1,273	49,696

Table 6.—Pyrites (ores and concentrates) sold and used in the United States

(Thousand long tons and thousand dollars)

Year	Sold			Used			Total sold and used [1]		
	Gross weight	Sulfur content	Value	Gross weight	Sulfur content	Value	Gross weight	Sulfur content	Value
1964	50	24	$239	798	330	$5,232	847	354	$5,471
1965	57	27	272	818	326	5,061	875	354	5,333
1966	52	25	205	820	330	4,883	872	356	5,088
1967	48	24	184	813	331	7,759	861	355	7,943
1968	56	28	W	816	334	W	872	362	W

W Withheld to avoid disclosing individual company confidential data.
[1] Data may not add to totals shown because of independent rounding.

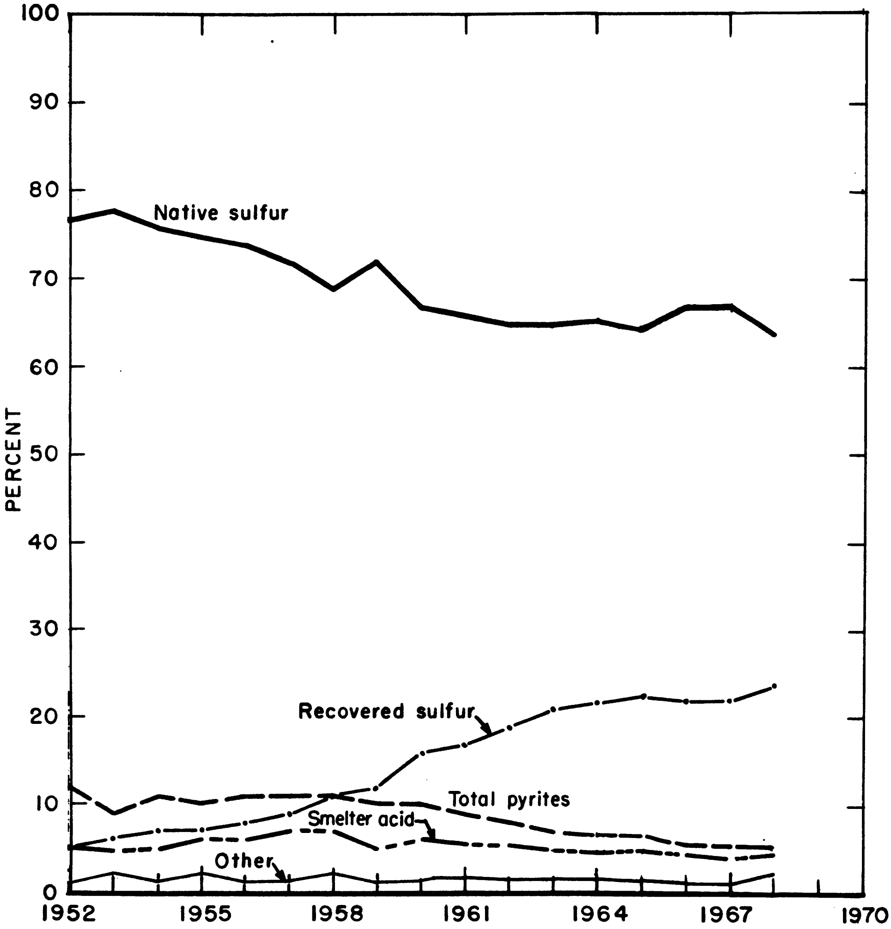

Figure 2.—Sulfur supply sources as a percent of total apparent consumption based on sulfur content.

Table 7.—Byproduct sulfuric acid[1] (100-percent basis) produced in the United States

(Thousand short tons)

Year	Copper plants[2]	Zinc plants[3]	Total[4]
1964	330	924	1,254
1965	369	962	1,331
1966	470	983	1,453
1967	348	900	1,249
1968	483	990	1,473

[1] Includes acid from foreign materials.

[2] Includes acid produced at a lead smelter. Excludes acid made from pyrites concentrates in Arizona, Montana, Tennessee, and Utah.

[3] Excludes acid made from native sulfur.

[4] Data may not add to totals shown because of independent rounding.

American Smelting & Refining Company announced that it is constructing a new 750-ton-per-day sulfuric acid plant at its Hayden, Ariz., smelter. The plant, scheduled for completion in mid-1970, will use sulfur dioxide which discharges to the atmosphere, thus contributing to the firm's program for cleaner air. The increased demand for sulfuric acid in the Arizona-New Mexico area for water treatment, fertilizer, and leaching copper ores also were factors for erecting the acid plant.

CONSUMPTION

The apparent consumption of sulfur, all forms, was the third largest in history and only 2.32 percent less than the record of 1967.

Sulfur was consumed mostly as acid largely to produce fertilizers (major use); refine petroleum; produce inorganic pigments, alcohols, rayon, and explosives; pickle iron and steel; leach copper ores; and produce pulp, paper, and cellulosic fibers. Sulfur's nonacid uses were largest in the production of pulp, paper, and cellulosic fibers.

The consumption of sulfur in the free world probably reached almost 27 million long tons in 1968, approximately half being used to produce fertilizers.

Table 8.—Apparent consumption of native sulfur in the United States

(Thousand long tons)

	1964	1965	1966	1967	1968
Apparent sales to consumers [1]	5,775	6,938	7,687	7,729	6,649
Imports	891	831	799	724	742
Total [2]	6,666	7,769	8,486	8,453	7,391
Exports:					
Crude	1,920	2,624	2,326	2,043	1,549
Refined	8	11	47	150	53
Total [2]	1,928	2,635	2,373	2,193	1,602
Apparent consumption	4,738	5,134	6,113	6,260	5,789

[1] Production adjusted for net change in stocks during year.
[2] Data may not add to totals shown because of independent rounding.

Table 9.—Apparent consumption of sulfur in all forms in the United States[1]

(Thousand long tons)

	1964	1965	1966	1967	1968
Native sulfur	4,738	5,134	6,113	6,260	5,789
Recovered sulfur:					
Sales	988	1,167	1,258	1,287	1,332
Imports	571	656	715	750	830
Pyrites:					
Domestic	354	354	356	355	362
Imports	120	160	160	165	140
Total	474	514	516	520	502
Smelter acid	366	388	424	364	430
Other [2]	[r]118	[r]123	[r]119	[r]119	202
Grand total [3]	[r]7,255	[r]7,981	[r]9,145	[r]9,301	9,085

[e] Estimated. [r] Revised.
[1] Crude sulfur or sulfur content.
[2] Hydrogen sulfide and liquid sulfur dioxide. Does not include acid sludge converted to H_2SO_4.
[3] Data may not add to totals shown because of independent rounding.

STOCKS

At yearend producers stocks of Frasch sulfur totaled 2,711,016 long tons while producers stocks of recovered sulfur totaled 79,217 long tons. The yearend Frasch sulfur stocks were the largest since November 1966 and the yearend recovered sulfur stocks, the largest since January 1967.

PRICES

Oil, Paint and Drug Reporter quoted the following prices for sulfur, sulfuric acid, and pyrites.

Crude, domestic, dark, bulk sulfur, f.o.b. cars, mines, and f.o.b. vessels, Gulf ports (for U.S. and Canada) was quoted at $38 per long ton until March 15, and then $41 per ton. Bright sulfur prices were $1 per long ton higher. Bright sulfur for export and on long term contracts, f.o.b. vessels, Gulf ports, was quoted at $39 per long ton until January 5, then $40 until March 15, and then $41. Sulfuric acid, 100 percent, tanks, works was quoted at $33.40 per short ton until April 5, and then $34.65. Canadian pyrites containing 48 to 50 percent sulfur, were quoted at $4.50 to $5 per long ton at mines.

FOREIGN TRADE

Exports of crude sulfur, the smallest since 1962, went to more than 50 countries of which more than 35 percent was shipped to the Netherlands.

Exports of other sulfur totaling 52,786 long tons were made to more than 40 countries of which 33 percent went to Brazil, and almost 19 percent each to India and Italy. Other exports which were reported, included 1,681 short tons, of unroasted iron pyrites valued at $61,426 to nine countries, 77 percent of which was delivered to Sweden and Canada; and 6,437 short tons of sulfuric acid valued at $402,096, to about 70 countries, 29 percent of which went to Canada.

Imports for consumption of sulfur, shown in table 12, were among the largest. Other sulfur-bearing imports included 9,548 short tons of sulfur dioxide valued at $225,802 from Canada; and 147,313 short tons of sulfuric acid valued at $2,625,762 from four countries, the largest imports being 128,239 short tons valued at $2,309,347 from Canada.

Imports of pyrites in 1968 were estimated at 280,000 long tons containing 140,000 tons of sulfur. Official Bureau of the Census data, which do not include all shipments, reported a much lower figure.

Table 10.—U.S. exports and imports for consumption of sulfur

(Thousand long tons and thousand dollars)

Year	Exports				Imports	
	Crude		Crushed, ground, refined, sublimed, and flowers			
	Quantity	Value	Quantity	Value	Quantity	Value
1966	2,326	$78,759	47	$3,404	1,514	$33,525
1967	2,043	81,492	150	9,522	1,474	47,612
1968	1,549	65,650	53	3,855	1,572	64,277

Table 11.—U.S. exports of sulfur, by countries

Destination	Crude				Crushed, ground, refined, sublimed and flowers			
	1967		1968		1967		1968	
	Long tons (thousands)	Value (thousands)	Long tons (thousands)	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
Argentina	25	$1,056	15	$686	56	$25	109	$29
Australia	223	8,464	82	3,436	297	92	262	67
Austria	31	1,254	8	322	-------	-------	-------	------
Belgium-Luxembourg	30	1,191	57	2,382	14	5	24	3
Brazil	192	7,652	132	5,710	411	106	17,472	925
Canada	123	4,554	81	3,343	813	236	1,874	380
Chile	4	185	-------	-------	2	1	4,486	219
Colombia	1	55	-------	-------	119	29	133	32
El Salvador	8	368	4	184	63	11	5	1
France	5	195	22	913	63	28	123	34
Germany, West	66	2,647	9	356	17	3	40	6
India	131	6,195	46	2,261	90,252	5,695	10,172	690
Ireland	77	3,031	95	4,016	-------	-------	-------	------
Israel	34	1,444	18	827	1	(1)	20	4
Italy	5	238	48	2,215	5,883	261	10,000	620
Jamaica	2	96	1	56	1,134	64	7	2
Korea, South	3	213	-------	-------	1,070	76	-------	------
Mexico	--------	-------	-------	-------	233	82	459	82
Netherlands	564	21,978	549	22,673	-------	-------	-------	------
New Zealand	64	2,452	64	2,626	86	18	95	25
Norway	6	224	2	98	36	3	36	3
Pakistan	--------	-------	(1)	1	4	1	117	20
Peru	17	665	(1)	5	102	31	149	31
Philippines	(1)	7	(1)	5	3,567	236	80	37
Saudi Arabia	1	66	1	62	318	24	406	35
South Africa, Republic of	67	2,123	56	2,027	15,521	743	249	41
Sweden	9	343	10	443	-------	-------	21	8
Taiwan	73	3,675	29	1,466	11,752	743	4,208	300
Tunisia	51	1,974	48	2,053	-------	-------	-------	------
United Kingdom	150	5,745	110	4,562	85	17	442	28
Uruguay	10	482	3	150	-------	-------	912	62
Venezuela	2	108	11	674	17,139	841	397	74
Other	69	2,862	48	2,098	787	151	488	97
Total	2,043	81,492	1,549	65,650	149,825	9,522	52,786	3,855

[1] Less than ½ unit.

Table 12.—U.S. imports for consumption of sulfur, by countries

(Thousand long tons and thousand dollars)

Country	1967		1968	
	Quantity	Value	Quantity	Value
Australia	-----	--------	(1)	$1
Canada	750	$18,371	830	26,442
Germany, West	(1)	12	(1)	17
Japan	(1)	8	-------	--------
Mexico	724	29,221	742	37,817
United Kingdom	(1)	(1)	-------	--------
Total	1,474	47,612	1,572	64,277

[1] Less than ½ unit.

WORLD REVIEW

Canada.—The principal sulfur plants in Canada together with their individual daily rated outputs and estimated annual output of sulfur in 1967 were listed.[4] The estimated output of sulfur in Canada in 1967 was reported as follows: 2.9 million short tons from 23 plants treating sour gas;

---

[4] Cote, R. R., and W. E. Koepke. Sulphur. Canadian Minerals Yearbook 1967, preprint, June 1968, 11 pp.

Table 13.—World production of elemental sulfur, by countries

(Thousand long tons)

Country	1964	1965	1966	1967	1968 [p]
Native sulfur:					
Frasch:					
Mexico	1,636	1,482	1,611	[r] 1,790	1,582
Poland	------	--------	--------	227	816
United States	5,228	6,116	7,002	7,014	7,458
Total	6,864	7,598	8,613	[r] 9,031	9,856
From sulfur ores:					
Argentina	22	23	30	32	32
Bolivia (exports)	11	9	57	49	35
Canary Islands	10	[e] 7	[e] 7	[e] 7	7
Chile	43	35	[r] 39	55	61
China, mainland [e]	[r] 118	[r] 118	[r] 118	[r] 118	[r] 118
Colombia	12	18	21	24	28
Ecuador	(1)	(1)	(1)	(1)	(1)
Indonesia	2	[r] 4	[e] 1	[r] [e] 1	[e] 1
Italy	95	94	92	[r] 82	96
Japan [2]	237	210	226	250	256
Mexico	26	34	29	24	24
Poland	290	424	469	484	479
Taiwan	6	4	5	3	[e] 3
Turkey	22	22	22	25	24
U.S.S.R. [e]	[r] 935	[r] 984	[r] 984	[r] 1,034	1,038
United States	(1)	(1)	(1)	(1)	2
Total [3]	[r] 1,829	[r] 1,986	[r] 2,100	[r] 2,188	2,199
Total native sulfur	[r] 8,693	[r] 9,584	[r] 10,713	[r] 11,219	12,055
Other elemental:					
Recovered:					
Belgium	5	3	5	[e] 5	[e] 5
Brazil [4]	5	5	6	6	7
Bulgaria [5]	7	10	[e] 11	[e] 10	[e] 10
Canada [6]	1,597	1,847	1,823	[r] 2,231	2,308
China, mainland [e] [4] [5]	[r] 128	[r] 128	[r] 128	[r] 128	[r] 128
Finland	67	73	72	[r] 103	123
France [7]	1,487	1,497	1,516	[r] 1,639	1,589
Germany:					
East	123	123	126	[r] 121	[e] 123
West	77	75	78	[r] 103	125
Hungary	3	4	3	3	[e] 3
Iran [e] [4]	20	20	[r] 25	25	25
Italy	1	2	[e] 2	[e] 2	[e] 2
Japan [4]	18	36	52	61	73
Mexico [7]	36	46	38	48	52
Netherlands [5]	28	26	[r] 45	42	[e] 46
Netherlands Antilles [e]	28	30	[r] 29	30	30
Portugal	6	10	6	(1)	[e] (1)
South Africa, Republic of [4]	6	7	[r] 6	[r] 6	[e] 6
Spain	75	43	28	[r] 41	[e] 39
Sweden [8]	27	21	10	--------	--------
Taiwan [4]	3	2	2	3	[e] 3
Trinidad [4]	5	4	4	[e] 2	3
U.S.S.R. [e]	[r] 394	[r] 423	[r] 423	[r] 443	443
United Arab Republic	2	4	11	[e] 12	3
United Kingdom [9]	54	48	40	46	[e] 49
United States	1,021	1,215	1,240	1,268	1,354
Uruguay [4]	------	--------	--------	(1)	[e] (1)
Total other elemental	[r] 5,223	[r] 5,702	[r] 5,729	[r] 6,378	6,549
Grand total	[r] 13,916	[r] 15,286	[r] 16,442	[r] 17,597	18,604

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Less than ½ unit.

[2] Includes sulfur from mined sulfur-sulfide ore.

[3] In some years Iran produces mine sulfur equivalent to 250 to 1,500 tons of sulfur. No estimate in total.

[4] From refinery gases.

[5] From sulfide ore.

[6] Produced from natural gas; includes small quantities from domestic crude oil and treatment of nickel-sulfide matte.

[7] From natural gas.

[8] From shale oil.

[9] Including sulfur recovered from petroleum refineries.

115,000 tons from one plant treating oil sands; 142,000 tons from various oil refineries; and 755,000 tons of equivalent sulfur from eight plants which produced sulfuric acid. The report also gave the names of four sulfide ore producers.

Alberta's established reserves of recoverable sulfur in natural gas were estimated at yearend 1967 at more than 117 million long tons. The distribution of these reserves according to plants, gasfields, geological formations, volume of recoverable raw gas remaining, the hydrogen sulfide content of the raw gas, and recovery efficiencies was reported.[5]

Commercial Solids Pipeline Co., a subsidiary of Shell Canada Ltd., secured parliamentary approval for constructing a 750-mile-long, 12-inch-diameter pipeline to transport sulfur from Calgary, Alberta, to the Pacific Coast. The pipeline is expected to cost $60 million and transport 1,600 tons of sulfur per day.[6]

A new multimillion-dollar sulfur extraction plant that will produce 1,480 long tons of sulfur and 50 million cubic feet of sweetened residue gas daily and reportedly the third largest of its type in North America was placed onstream by Pan American Petroleum Corp. near Crossfield,

---

[5] Bureau of Mines. Mineral Trade Notes. V. 65, No. 8, August 1968, pp. 28–32.

[6] Sulphur. Project to Establish 750-Mile Sulphur Pipeline Under Way. No. 76, May–June 1968, p. 44.

Table 14.—World production of pyrites (including cupreous pyrites)

(Thousand long tons)

Country [1]	1966		1967		1968 [p]	
	Gross weight	Sulfur content	Gross weight	Sulfur content	Gross weight	Sulfur content
North America:						
Canada (shipments)	[r] 292	145	[r] 337	[e] 167	286	[e] 142
United States	872	356	861	355	872	362
Europe:						
Bulgaria	[r] 145	[r] 61	[e] 148	[e] 62	[e] 148	[e] 62
Czechoslovakia	346	[e] 135	370	[e] 157	NA	NA
Finland	508	[r] 245	700	336	762	365
France	87	36	84	35	[e] 82	[e] 33
Germany:						
East	127	53	127	53	[e] 138	[e] 57
West	443	203	547	232	[e] 603	248
Greece	133	[e] 60	177	[e] 83	207	[e] 96
Italy	1,284	578	1,389	625	1,384	623
Norway	667	297	627	282	677	[e] 305
Poland [e]	236	90	236	89	236	90
Portugal	549	253	520	239	544	250
Rumania [e]	354	138	354	138	354	138
Spain	2,380	1,115	2,255	1,070	2,365	1,132
Sweden	427	218	475	[e] 242	[e] 512	[e] 261
U.S.S.R. [e]	3,248	1,722	3,445	1,821	3,445	1,821
Yugoslavia	372	156	418	175	243	113
Africa:						
Algeria [e]	49	23	59	28	59	27
Morocco [2]	[r] 292	[r] 93	348	108	411	123
South Africa, Republic of	474	[e] 189	544	[e] 218	578	[e] 231
Asia:						
China, mainland [e]	1,476	[r] 669	1,476	669	1,476	669
Cyprus	[r] 791	380	848	411	860	413
Japan [3]	4,659	1,958	4,457	1,878	4,405	[e] 1,870
Korea:						
North [e]	492	197	492	197	492	197
South	4	[e] [r] 1	4	[e] 1	NA	NA
Philippines	113	51	144	67	179	84
Taiwan	41	17	38	15	38	[e] 14
Turkey	171	81	123	59	135	71
Oceania: Australia	246	107	253	111	[e] 246	[e] 108
Total [4]	[r] 21,278	[r] 9,627	21,856	9,923	21,737	9,905

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Pyrites are produced in Cuba, but there is too little information to estimate production. Pyrites are also produced in Southern Rhodesia, but production figures have been withheld by the Government.

[2] Contains 282,311 tons pyrrhotite in 1966 and all pyrrhotite in 1967 and 1968.

[3] Pyrite data covering pyrites, cupreous pyrites, and pyrrhotite only are as follows: 1966, 3,562,883; 1967, 3,498,817; and 1968 NA.

[4] Total is of listed figure only.

Alberta. The raw gas feed for sulfur removal is supplied at the rate of 106 million cubic feet per day from 36 wells. Pan American owns almost 40 percent of the plant and it will operate the plant for itself and 23 other firms and individuals.[7]

India.—India depends upon imports for its sulfur supply and 90 percent of it is used to produce sulfuric acid for fertilizers and chemicals. Imports of sulfur in 1967 totaled 583,307 long tons valued at $42.7 million. However, India will soon obtain part of its sulfur requirements from domestic sources. Two new electrolytic smelters, Cominco Binani in Kerala and Hindustan Zinc in Rajasthan, will have a combined annual capacity of 73,800 tons of byproduct sulfuric acid. The Madras Petroleum Refinery, scheduled for completion 1969, will have an annual capacity of 17,700 tons of sulfur or 50,200 tons of sulfuric acid. In addition, the Amjhore-Ghogha pyrite deposits in Bihar are expected to yield 85,000 tons of sulfur or 241,500 tons of 98-percent sulfuric acid annually when in full production.[8]

Norway.—The operations of Norway's primary and secondary producers of pyrites were listed and described.[9]

Poland.—The Piaseczno mine, near Tarnobrzeg, which started to operate about 10 years ago, currently produces about 500,000 tons of sulfur annually. The deposit is said to extend over a 50-mile area and contain 100 million tons of sulfur. The ore, containing 21 to 24 percent sulfur, is 15 to 30 feet thick and overlain by approximately 200 feet of overburden which is removed by strip mining methods. Output may be doubled by 1970, and tripled by 1973.[10]

Spain.—Huelva City continued to attract sulfuric acid operations. Interquimica S.A., a new fertilizer complex, planned to construct plants to produce 350,000 tons of sulfuric acid and 130,000 tons of phosphoric acid annually. Rio Tinto Co., Ltd., together with Union Espanola de Explosivos and Sociedad Anomina Crosa, was erecting a 330,000-ton-capacity sulfuric plant to come on stream in 1969. Rio Tinto, already operating a large sulfuric acid plant, had plans to enlarge its facilities by 180,000 tons annually.[11]

TECHNOLOGY

A comprehensive study was made on sulfur's sources, consumption in industry, consumption in fertilizer, and prices and costs.[12]

The thermal, wet, and microbiological methods of recovering sulfur from anhydrite and gypsum and also six pyrometallurgical, two hydrometallurgical, and two electrolytic processes of recovering sulfur from sulfide ores were discussed.[13]

The operations of Freeport Sulphur Co.'s new Caminada mine and its 8-year-old Grand Isle mine, both of which are Frasch sulfur mines operated from platforms located 7 miles offshore Louisiana and 7 miles apart, were compared.[14] The Caminada project cost $25 million compared with $30 million for the older operation. The Caminada sulfur deposit is larger and thinner than the Grand Isle and the annual output of sulfur at Caminada is expected to be smaller, the Grand Isle currently producing more than 1 million tons of sulfur annually. The top decks of the platform at Caminada mine are 75 to 85 feet above the water compared with 60 feet for the older operation. Caminada's power plant capacity is about the same as Grand Isle's which produces 360,000 pounds of steam per hour at 600 pounds per square inch and 600° F, generating 4,500 killowatts at 2,400 volts. Caminada has two compact boilers in contrast to Grand Isle's four, the newer operation using a computer for automated starting and shutdown of boilers. The molten sulfur from Caminada, as at Grand Isle, will be pumped to shore through pipelines.

---

[7] Bureau of Mines. Mineral Trade Notes. V. 65, No. 5, May 1968, pp. 26–27.

[8] Bureau of Mines. Mineral Trade Notes. V. 65, No. 9, September 1968, pp. 29–30.

[9] Sulfur. Norway—The Pyrites Industry and Its Potential (Part 1). No. 74, January–February 1968, pp. 13–18; (Part 2), No. 75, March–April 1968, pp. 19–22.

[10] Frank Ernest H. Sulfur, a Basic Industry Study. First Manhattan Co., New York, May 24, 1968, p. 24.

[11] Industrial Minerals (London). Spain—Another Acid Plant Planned for Huelva. No. 15, December 1968, p. 30.

[12] Frank, Ernest H. Sulfur, A Basic Industry Study. First Manhattan Co., 30 Wall St., New York, May 24, 1968, 93 pp.

[13] Habashi, Fathi. Processes for Sulfur Recovery From Ores. Pres. at Am. Min. Cong. Mining Show, Las Vegas, Nev., Oct. 7–10, 1968, 17 pp.

[14] Chemical Week. Key to Cheaper Sulfur From Sea. V. 102, No. 24, June 15, 1968, pp. 35–36.

A catalytic self-regenerative process for producing 20 to 25-percent sulfuric acid solution from waste gases from smelters and other high sulfuric dioxide sources was reported.[15]

Bureau of Mines research was successful in removing 90 percent of the sulfur from molybdenite flotation concentrate. The concentrate was compacted with one-fourth of its weight of aluminum powder, heated at 800° C for one-half hour, and the residue leached with water. The hydrogen sulfide derived from hydrolysis was suitable for conversion to elemental sulfur by the Claus method. In addition, at least 95 percent of the molybdenum was recoverable by allowing the residue from hydrolysis to oxidize and then extract the molybdenum with liquid ammonia.[16] In other research, a method was developed for determining the SO_3 and total oxides of sulfur in flue gases.[17] Sulfur content data were obtained during the routine analysis of 1,060 domestic crude oils for 1955–66 and of 201 foreign crude oils for 1966. The weighted average sulfur content of the domestic crude oils decreased from 0.73 to 0.67 percent between 1955 and 1966.[18]

Sulfur analyzing 99.9 percent purity was successfully produced from volcanic ash containing 20 percent sulfur in experiments at the Colorado School of Mines. Solvent extraction techniques were employed.[19]

A new mass spectrometer technique based on the ratios of two sulfur isotopes—S^{32} and S^{34}—in samples, reportedly can be used to quickly determine the extent of sulfur deposits. Operation of the tool depends upon the presence of bacteria in the samples and bacterial action. The technique reportedly can measure enrichments of sulfur as small as 0.05 percent.[20]

---

[15] Chemical & Engineering News. Add Another Process for Removing Sulfur Dioxide From Stack Gases. V. 46, No. 34, Aug. 12, 1968, p. 39.

[16] Haver, E. P., K. Uchida, and M. M. Wong. Recovery of Sulfur From Molybdenite. BuMines Rept. of Inv. 7185, 1968, 15 pp.

[17] Smith, J. E., J. A. Hultz, and A. A. Orning. Sampling and Analysis of Flue Gas for Oxides of Sulfur and Nitrogen. BuMines Rept. of Inv. 7108, 1968, 21 pp.

[18] McKinney, C. M., and Ella Mae Shelton. Sulfur Content of Crude Oils of the Free World. BuMines Rept. of Inv. 7059, 1967, 36 pp.

[19] Chemical Engineering. A Pilot Plant To Test a New Process for Extracting Elemental Sulfur From Volcanic Ash. V. 46, No. 52, Dec. 9, 1968, p. 47.

[20] Chemical & Engineering News. Sulfur Located by Shallow Sampling Method. V. 46, No. 52, Dec. 9, 1968, pp. 48–49.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/45

Talc, Soapstone, and Pyrophyllite

By John W. Hartwell [1]

Production of talc, soapstone, and pyrophyllite in the United States during 1968 rose substantially over output in 1967, establishing a new record. However, the total value decreased about 3 percent, chiefly because of the higher percentage of low-unit-value material mined. Production was reported from 75 mines, most of which were located in California. World production increased, 9 percent.

Legislation and Government Programs.—The Government stockpile inventory as of June 30, 1968, listed stocks of talc and steatite at 1,244 short tons of block and lump, of which 1,044 tons valued at $300-000 was surplus, and 3,900 short tons of ground material valued at $200,000. There is no stockpile objective for the ground material. Both the excess ground material and the block and lump have been authorized for disposal.

Table 1.—Salient talc, soapstone, and pyrophyllite statistics

(Thousand short tons and thousand dollars)

	1964	1965	1966	1967	1968
United States:					
Mine production	890	863	895	903	958
Value	$6,218	$6,343	$6,479	$6,871	$6,656
Sold by producers	875	838	850	824	886
Value	$19,233	$19,794	$19,269	$20,488	$21,704
Exports [1]	74	70	70	66	66
Value [1]	$3,391	$3,486	$3,917	$3,450	$3,521
Imports for consumption	23	21	22	15	24
Value	$917	$833	$827	$653	$973
World: Production	3,878	3,934	4,093	4,352	4,738

[1] Excludes talcum (in package), face, and compact powders.

DOMESTIC PRODUCTION

The total domestic talc, soapstone, and pyrophyllite production in 1968 increased 6 percent over the quantity reported in 1967. Production was from 15 States, with seven States accounting for about 95 percent of the total output. These seven States, in order of decreasing production, were New York, California, Vermont, Texas, North Carolina, Montana, and Georgia. Increased production was reported principally from California, New York, and Texas.

Western Talc Co., Inc., completed a modernization and expansion of its talc property near Tecopa, Calif. The objective of this program was to increase output of talc and clay products to 300 short tons per day.

The Piedmont Minerals Co., Inc., Greensboro, N.C., was in the process of expanding milling and storage capabilities at its mill in Hillsborough. Increased mine production of talc, pyrophyllite, and andalusite was planned. Water usage in the milling operation was expected to increase from 100,000 gallons per day in 1969 to 400,000 gallons per day by 1973.

---

[1] Mining engineer, Bureau of Mines, Pittsburgh, Pa.

The White Eagle talc mine near Willow Camp in the northwest end of Saline Valley, Calif., was opened in 1968 by the Bishop Mining & Milling Co. The ore will be processed at the mill near Bishop.

Table 2.—Crude talc, soapstone, and pyrophyllite produced in the United States, by States

State	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
California	143,466	$1,945	165,396	$2,075
Georgia	46,150	292	45,600	288
Nevada	2,096	17	3,029	38
North Carolina	109,393	513	100,030	520
Oregon	2	(1)	3	1
Texas	90,836	356	125,880	517
Virginia	W	W	3,928	10
Washington	4,916	26	W	W
Other States [2]	505,655	3,722	514,396	3,207
Total	902,512	6,871	958,262	6,656

W Withheld to avoid disclosing individual company confidential data.

[1] Less than ½ unit.

[2] Includes Alabama, Arkansas, Maryland, Montana, New York, Pennsylvania, Vermont, and States indicated by symbol W.

Table 3.—Talc, soapstone, and pyrophyllite sold by producers in the United States, by classes

Year	Crude		Ground [1]		Total	
	Short tons	Value at shipping point (thousands)	Short tons	Value at shipping point (thousands)	Short tons	Value at shipping point (thousands)
1964	73,438	$371	801,587	$18,863	875,025	$19,233
1965	63,345	255	775,079	19,539	838,424	19,794
1966	[2] 110,856	493	738,736	18,776	849,592	19,269
1967	[2] 42,758	280	780,998	20,208	823,756	20,488
1968	[2] 64,877	331	821,601	21,373	886,478	21,704

[1] Includes crushed and sawed and manufactured material to avoid disclosing individual company confidential data.

[2] Includes exports to grinders in Belgium and Mexico.

CONSUMPTION AND USES

Consumption of talc, soapstone, and pyrophyllite in the United States increased 7 percent in 1968 according to information supplied by producers and grinders. The quantity sold or used by producers in 1968 was 886,000 short tons.

Reports indicate that the amount of talc used by the paper manufacturers will increase to about 50,000 short tons by 1975. Sales in 1968 dropped 17 percent below 1965 sales of nearly 47,000 short tons.

The quantity of talc, soapstone, and pyrophyllite used by the ceramic and paint industries in 1968 increased 11 percent over 1967. In comparison to the total consumption by all industries, the percentage used by the ceramic and paint consumers has been in a general decline since 1963 when 56 percent of the total quantity used was consumed by these industries.

Although the quantity of the talc-group minerals consumed by the cosmetic, textile, and roofing industries in 1968 increased 28 percent over 1967, the percent of use in recent years has remained fairly constant. Consumption by all other industries has also remained constant but total quantity used declined slightly in 1968.

Table 4.—Pyrophyllite[1] produced and sold by producers in the United States

Year	Production	Total sales	
	Short tons	Short tons	Value (thousands)
1964	136,108	142,532	$1,843
1965	126,266	136,308	1,824
1966	125,202	126,874	1,627
1967	117,457	118,337	1,579
1968	130,624	120,319	1,748

[1] Includes sericite schist.

Table 5.—Talc, soapstone, and pyrophyllite sold or used by producers in the United States, by uses

(Short tons)

Use	Talc and soapstone		Pyrophyllite	
	1967	1968	1967	1968
Ceramics	203,438	227,327	15,623	20,657
Foundry facings	5,818	W	---------	---------
Insecticides	40,759	38,739	27,598	W
Paint	151,752	166,336	W	W
Paper	45,046	38,897	---------	---------
Roofing	71,434	84,699	---------	---------
Rubber	27,937	20,897	W	W
Textile	8,384	13,520	W	W
Toilet preparations	26,996	33,930	W	W
Other	[1] 123,855	[1] 141,814	[2] 75,116	[2] 99,662
Total [3]	705,419	766,159	118,337	120,319

W Withheld to avoid disclosing individual company confidential data.

[1] Includes asphalt filler, carving, composition floor and wall tile, crayons, drugs, exports, fertilizer, grease manufacture, insulated wire and cable, joint cement, plastics, rice polishing, vault manufacturing, miscellaneous products, and items indicated by symbol W.

[2] Includes asphalt filler, brick, crayons, enamel coating, exports, joint cement, refractories, miscellaneous products, and items indicated by symbol W.

PRICES

Eastern U.S. talc producers increased prices early in 1967, while Western producer prices remained steady. Late in 1968, however, these Western producers increased their prices of better grade material from $2 to $5 per ton. Generally prices of talc are negotiated between buyer and seller.

FOREIGN TRADE

U.S. producers of talc, soapstone, and pyrophyllite in 1968 exported nearly 66,000 tons, valued at $3.5 million. About half the material, in both terms of quantity and value was shipped to Canada.

Although the total quantity exported was practically the same as that in 1967, the value increased slightly due to the rise in domestic prices. However, exports were down 11 percent from 1964 shipments, which were the largest ever exported from the United States.

Imports of all unmanufactured talc during 1968 increased 58 percent over those in 1967. Shipments from Canada of crude and unground talc were the highest ever recorded and increased 217 percent over those in 1967. Total imports of all grades from Canada were more than double the 1967 quantity and nearly double the imports from its nearest competitor, France. However, the value of the Canadian imports was 14 percent less than the value of the French imports.

Table 6.—U.S. exports of talc, soapstone, and pyrophyllite, crude and ground

(Thousand short tons and thousand dollars)

Year	Quantity	Value
1966	70	$3,917
1967	66	3,450
1968	66	3,521

Table 7.—U.S. imports for consumption of talc, steatite or soapstone, and French chalk, by classes and countries

Year and country	Crude and unground		Ground, washed, powdered, or pulverized, except toilet preparations		Cut and sawed		Total unmanufactured	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value [1] (thousands)
1966	341	$8	21,310	$680	257	$139	21,908	$827
1967								
Australia	11	1	10	1	------	------	21	2
Belgium-Luxembourg	------	------	28	6	------	------	28	6
Canada	2,850	29	2,147	47	6	1	5,003	77
France	------	------	4,985	122	1	(2)	4,986	122
India	20	2	------	------	------	------	20	2
Israel	------	------	10	2	------	------	10	2
Italy	32	(2)	4,379	281	7	4	4,418	285
Japan	1	(2)	------	------	200	124	201	124
Korea, South	------	------	670	28	1	(2)	671	28
Switzerland	------	------	------	------	3	5	3	5
Total	2,914	32	12,229	487	218	134	15,361	658
1968								
Canada	9,048	90	2,014	45	2	2	11,064	137
France	------	------	5,968	160	1	1	5,969	161
Germany, West	------	------	------	------	3	188	3	188
India	22	2	------	------	------	------	22	2
Italy	959	41	4,407	246	------	------	5,366	287
Japan	------	------	165	7	210	126	375	133
Korea, South	------	------	1,501	62	6	2	1,507	64
Mexico	2	(2)	------	------	------	------	2	(2)
United Arab Republic	5	1	------	------	------	------	5	1
Total	10,036	134	14,055	520	222	319	24,313	973

[1] Does not include talc, n.s.p.f.: 1966, $7,131; 1967, $4,938; and 1968, $12,722.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—An agreement was made with the United Sierra Division of Cyprus Mines to take over the marketing of talc produced by Three Springs Talc (Pty.) Ltd. Sales will be made throughout the world except in Australia and New Zealand. Talc production in 1968 is expected to total about 25,000 tons, and to continue increasing each year until 1976, when output will level off at 55,000 to 66,000 tons per year. Sales in 1966 and 1967 were 13,365 and 7,900 tons, respectively.

Botswana.—Talc deposits in the Moshaneng area were investigated by the Government in cooperation with the United Nations Development Plan. Over 270 tons were produced during the year from this area for marketing and use tests. Minor color impurities were causing difficulties in obtaining buyers.

Canada.—Improvements in the beneficiation of talc from the Banker Talc, Ltd., mines were successful on a small scale.

The material, because of its higher quality and brightness, became competitive as a filler in paint and in cosmetics uses. Production from this mine averages about 9,500 tons per year.

Finland.—Production of filler-grade talc was expected to start before mid-1969 from the Lohnaslampi deposit near Sotkamo in northern Finland. A new company, Suomen Talkki Oy., headed by Lohjan Kalkkitehdas, was formed to develop the property. Talc will be recovered as a flotation product and used principally in paper manufacture. Reserves of talc were reportedly large.

Greece.—A talc deposit on the island of Crete was reportedly being developed. Eighty percent of the yearly output was expected to be exported. A Greek company was to be formed to manage the property, and plans were made to purchase mining equipment from West Germany.

Korea, South.—Talc production continued to increase. Talc is the most important exported industrial mineral by value. Eleven mines were producing in 1967. The Fongyang mine, which had the largest production, increased its output to nearly 47,000 tons. The next biggest mine, the Shinbo, produced 5,000 tons. Pyrophyllite production also increased about 21 percent over 1966 output.

Table 8.—World production of talc, soapstone, and pyrophyllite, by countries

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada (shipments)	58,132	52,837	70,144	[r] 60,664	78,401
Mexico	[r] 865	[r] 3,733	[r] 2,767	[r] 3,217	707
United States	889,949	862,875	895,045	902,512	958,262
South America:					
Argentina	27,335	[r] 34,687	[r] 32,903	[e] 28,000	NA
Brazil	53,038	63,546	[e] 64,000	[e] 64,000	NA
Chile	3,042	4,822	2,813	3,176	3,101
Colombia	805	440	1,317	1,102	NA
Paraguay	52	154	66	79	83
Peru	[r] 3,959	[r] 4,621	4,227	4,926	NA
Uruguay	2,341	2,618	2,346	2,908	NA
Europe:					
Austria	79,225	83,668	84,110	[r] 85,685	[e] 86,000
Finland	9,062	7,716	5,516	2,824	[e] 3,000
France	226,414	264,872	[r] 246,999	[r] 227,074	[e] 232,000
Germany, West (marketable)	33,604	33,878	36,280	[r] 36,704	[e] 46,000
Greece	[r] 4,149	[r] 3,810	[r] 4,963	4,304	NA
Italy	[r] 147,025	[r] 133,880	[r] 124,702	[r] 130,586	[e] 125,000
Norway	[r] 84,014	[r] 84,857	[r] 88,298	[e] 88,000	[e] 88,000
Portugal	880	783	794	154	[e] 300
Rumania	[e] 110,000	126,765	[e] 132,000	143,299	[e] 143,000
Spain	29,550	[r] 30,663	[e] 32,000	[e] 31,000	[e] 31,000
Sweden	18,360	20,639	[r] 20,383	26,786	[e] 22,000
U.S.S.R.[e]	385,000	395,000	395,000	408,000	408,000
United Kingdom	11,374	11,174	[r] 10,110	[e] 11,000	[e] 11,000
Africa:					
Rhodesia, Southern	15	[e] 90	NA	NA	NA
South Africa, Republic of	7,294	10,187	9,530	10,071	9,978
Swaziland	2,199	1,014	480	660	640
United Arab Republic	18,542	43,682	[r] 32,670	NA	NA
Asia:					
China, mainland [e]	165,000	165,000	165,000	165,000	165,000
India	[r] 160,894	[r] 184,935	[r] 172,208	148,953	193,577
Japan	1,162,646	1,110,908	1,222,435	[r] 1,521,597	1,862,710
Korea:					
North [e]	44,000	55,000	55,000	55,000	66,000
South	99,272	93,306	119,379	135,443	164,692
Pakistan (soapstone)	2,821	3,135	3,618	2,920	[e] 3,000
Philippines	108	654	702	489	558
Taiwan	18,718	16,787	31,694	45,542	32,026
Thailand (pyrophyllite)	----------	----------	----------	14	3,707
Oceania:					
Australia	18,777	21,710	23,931	NA	NA
Total [1]	[r] 3,878,461	[r] 3,934,446	[r] 4,093,430	[r] 4,351,689	4,737,742

[e] Estimate. [p] Preliminary. [r] Revised. NA Not availalbe.

[1] Totals are listed figures only.

New Zealand.—A two-part report on the mineral resources of New Zealand was published. The second part of the report contains data on occurrences of talc. Only one talc mine, in the Cobb-Takaka District, was actively producing. The mined material is talc-magnesite and quartz-magnesite rock, and reserves were reportedly large. In 1967 about 600 tons were mined for use in fertilizers, fillers, etc.[2]

Zambia.—The Government reportedly started to develop the Lilaya and Chipata talc deposits for the purpose of establishing a local industry. Considerable marketing research has already been done.

TECHNOLOGY

New chemical, optical, and X-ray data were given for talc, tremolite, and a manganoan amphibole from the Gouverneur Mining District, N.Y.[3] The chemical and physical properties of talc from the Arnold pit were described in detail. Additional data on 22 talcs from worldwide localities indicated that talc derived from metamorphosed sedimentary rocks contains appreciable quantities of fluorine, while those from ultramafic rocks contain less.

A calcined white pigment, based on talc and having hydrophilic properties, might be used in papermaking and as a filler for latex paints.[4]

A process to obtain separate platy and granular fractions from talc ore, while eliminating the impurities, was recommended as an improved method of talc beneficiation.[5]

A report on the production, quality, uses, and specifications of talc from mines in France, Norway, Italy, Austria, India, and mainland China was published.[6]

A grade of talc was produced by a milling plant in Ghent, Belgium, which preferentially absorbs organic materials in the presence of water. This property has found use in combating oil-polluted waters and beaches.[7]

---

[2] U.S. Embassy, Wellington, New Zealand. State Department Dispatch A-68: Apr. 14, 1969.

[3] Ross, Malcolm, William L. Smith, and William A. Ashton. Triclinic Talc and Associated Amphiboles From Gouverneur Mining District, New York. Am. Miner., v. 53, Nos. 5 and 6, 1968, pp. 751–769.

[4] Lamar, R. S. (assigned to Cyprus Mines Corp.). Calcined Hydrophilic Talc Pigment. U.S. Pat. 3,366,501, Jan. 30, 1968.

[5] Bixby, D. H. (assigned to Resource Processors, Inc.). Talc Beneficiation Method. U.S. Pat. 3,414,201, Dec. 3, 1968.

[6] Industrial Minerals (London). Talc—Mineral With a Multitude of Uses. No. 5, February 1968, pp. 9–16.

[7] Industrial Minerals (London). World of Minerals. No. 12, September 1968, p. 32.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/32

Thorium

By Richard F. Stevens, Jr.[1]

Thorium continued to be recovered entirely from monazite beach sands primarily as a byproduct of rare-earth oxide (REO) production. The metals' use for both industrial and nuclear purposes remained fairly steady. Supply of thorium will probably continue to exceed demand until thorium is required as a nuclear fuel.

Legislation and Government Programs.—The U.S. Government's Supplemental Stockpile contained nearly 8 million pounds of thorium nitrate ($Th(NO_3)\cdot 4H_2O$) equivalent to over 3.6 million pounds of thorium oxide (ThO_2), compared with the stockpile objective of 500,000 pounds of contained ThO_2, which represents the Government's projected emergency requirements. Although the 3.1-million-pound surplus has been authorized for disposal by Congress, the material is currently available for government use only. Early in 1969 the stockpile objective was revised downward to 80,000 pounds of ThO_2 equivalent.

The U.S. Atomic Energy Commission (AEC) holds additional stocks of about 3.2 million pounds of thorium metal equivalent for use in nuclear research.

Although the AEC issued revised radiation protection standards (U.S. Code of Federal Regulations, 10 CFR, Part 20) during the year, the quantities listed for natural thorium (50 microcuries) remained unchanged because of the low specific activity of this source material and the attendant low risk of human intake of this material.

AEC requested expressions of interest from the domestic industry to produce dense thoria from thorium nitrate held in AEC stocks. This thoria will be used for the production of clean uranium-233 in AEC production reactors. Since only a small quantity of the thoria used is consumed, the remainder, after purification and separation will be returned to the AEC inventory.

DOMESTIC PRODUCTION

Mine Production.—Domestic monazite production in 1968, down 12 percent from that reported in 1967, came predominantly from the operations of the Humphreys Mining Co. on property owned by E. I. du Pont de Nemours & Co., Inc., at Folkston, Ga., and from the reworking of the tailings piles at the Skinner mine of the National Lead Co., Jacksonville, Fla. This reworking operation, conducted by the Carpco Research & Engineering Co., was discontinued early in 1968. In addition a small quantity of monazite continued to be recovered as a byproduct of molybdenum mining operations at the Climax Molybdenum Company's mine and mill near Leadville, Colo.

Although no production was reported from Idaho or Montana, the Union Pacific Railroad Co. (UP) finished a sampling and mapping investigation of deposits of thorium and associated rare-earth elements at Lemhi Pass, Beverhead County, Mont., on property owned by the Sawyer Petroleum Co. The UP also completed market studies on the sales potential for thorium, rare-earth elements, and yttrium. As a result of these studies and the development of a process to treat these ores by Nuclear Chemical Co., UP and Sawyer Petroleum tentatively decided to proceed with the development of this property and reportedly are conducting negotiations on the marketing of this material.

---

[1] Physical scientist, Division of Mineral Studies.

Two recent reports on the geology and analysis of the Lemhi Pass thorium resource deposits were prepared by the AEC.[2]

Refinery Production.—American Potash & Chemical Corp., a subsidiary of Kerr-McGee Corp., West Chicago, Ill., and the Davison Chemical Division of W. R. Grace & Co., Chattanooga, Tenn., continued to be the only domestic firms who processed monazite and produced rare-earth elements and thorium compounds. These two firms supplied both crude and refined products to other processors during the year. Since the monazite production rate continued to be determined by the demand for rare-earth compounds, the recovered thorium exceeded domestic demands and commercial thorium stocks experienced a continuing buildup. Magnesium-thorium hardeners were not produced domestically during 1968 and U.S. alloy producers relied upon imported master alloys (containing about 40 percent thorium) produced in the United Kingdom by Thorium Ltd. and distributed in the United States by Magnesium Elektron, Inc. of New York. The source of this thorium was believed to be material recovered as a byproduct of Canadian uranium mining operations.

Table 1.—Principal firms having capacity to process and fabricate thorium during 1968

Company	Plant location
American Potash & Chemical Corp	West Chicago, Ill.
The Babcock & Wilcox Co	Lynchburg, Va.
The Dow Chemical Co	Midland, Mich.
General Electric Co	San Jose, Calif.
Gulf General Atomic, Inc	San Diego, Calif.
W. R. Grace & Co	Chattanooga, Tenn.
Kerr-McGee Corp	Oklahoma City, Okla.
Metal Hydrides, Inc	Beverly, Mass.
National Lead Co	Albany, N.Y.
Nuclear Fuel Services, Inc	Erwin, Tenn.
Nuclear Materials & Equipment Corp. (NUMEC)	Apollo, Pa.
United Nuclear Corp	Hematite, Mo.

Source: U.S. Atomic Energy Commission. The Nuclear Industry 1968. Nov. 14, 1968, pp. 55, 59.

CONSUMPTION AND USES

Nonenergy Uses.—During 1968 the total apparent consumption of thorium in nonenergy uses continued the slightly rising trend which started in 1966 and was estimated to total about 125 tons of equivalent ThO_2 (thoria). Principal uses, in order of importance, continued to be as follows: Thorium nitrate used in the manufacture of Welsbach-type incandescent gas mantles (50 percent of total consumption); magnesium-base alloys contain about 3 percent thorium (30 percent); the use of ThO_2 in the production of dispersion-hardened metal such as stainless steel, nickel and tungsten (10 percent). In addition, a small quantity of ThO_2 was used in specialized refractories and as catalysts in the manufacturing of organic chemicals. Because both thoria and thorium boride are capable of withstanding temperatures up to 3,000° C, these compounds are being considered for use in elevated temperature applications. Minor amounts of other thorium compounds continued to be used in electronic devices such as electric discharge tubes, bolometers, radiation detectors, computer memory components, photoconductive films, and fuel-cell elements. The use of thorium, as thoria, in structural alloys for aerospace and military projects, while small in quantity, was of sufficient importance to justify its retention on the Government's list of strategic and critical materials.

Energy Uses.—The demand for thorium in nuclear-energy applications was very small and was supplied completely from the AEC's stockpile which had been ac-

Table 2.—Producers and fabricators of magnesium-thorium alloys[1]

Company	Plant location
American Light Alloys, Inc	Little Falls, N.J.
Bendix Foundries	Teterboro, N.J.
Brooks and Perkins, Inc	Detroit, Mich.
Controlled Castings Corp	Plainview, N.Y.
The Dow Chemical Co	Madison, Ill.
Hills—McCanna Co	Carpentersville, Ill.
R.C. Hitchcock and Sons, Inc	Minneapolis, Minn.
Howard Foundry Co	Chicago, Ill.
The Wellman Bronze & Aluminum Co	Bay City, Mich.

[1] Three percent thorium alloys.

---

[2] Austin, S. Ralph. Thorium, Yttrium, and Rare-Earth Analyses, Lemhi Pass—Idaho and Montana. U.S. Atomic Energy Commission, Grand Junction Office, Grand Junction, Colo., AEC-RID-2, April 1968, 12 pp. (open file report).
Sharp, Bryon J., and Donald L. Hetland. Thorium and Rare Earth Resources of the Lemhi Pass Area, Idaho and Montana. U.S. Atomic Energy Commission, Grand Junction Office, Grand Junction, Colo., AEC-RID-3, July 1968, 13 pp. (open file report).

cumulated prior to 1962. Of the five types of nuclear reactors adaptable to the thorium fuel cycle which are discussed in the Technology section, the high-temperature gas-cooled reactor (HTGR) and the molten salt converter reactor experiment (MSRE) are the farthest along in development. Both of these reactor systems have a potential for higher conversion ratios and greater thermal efficiencies than the present light-water uranium-fueled reactors. However, the complete development of thorium breeder reactors is expected to require another 15 to 20 years. Until these reactors are developed the accumulated requirements of thorium for nuclear energy purposes are not expected to total more than a few hundred tons.

PRICES

During 1968 the nominal price of monazite ore (sands) as quoted periodically in Metals Week ranged from $180 to $200 per long ton (based upon rare-earth oxide (REO) content only). This range is equivalent to 8 to 9 cents per pound. On the basis of the estimated thoria (ThO_2) content, the value of imports in 1968 reported by the Bureau of the Census averaged $215 per ton of contained ThO_2. This was $1 per ton less than the average value reported in 1967 and some $24 per ton greater than the average value reported in 1966.

The quoted price of thorium metal, pellets, and powder remained steady at the previous year's level of $15 per pound. During the year, thorium nitrate reportedly sold in the range from $2.25 to $3.50 per pound and the price of thorium oxide ranged from $6 to $12.30 per pound. The master magnesium-thorium alloy hardener containing 30 to 40 percent thorium was quoted at $11.50 to $12 per pound of contained thorium plus the market value of the contained magnesium (35.25 cents per pound). On this basis the cost of 40-percent thorium hardener was about $4.82 per pound.

FOREIGN TRADE

Exports.—Exports of thorium ore and concentrate during 1968 totaled 1,476 pounds of contained thorium oxide valued at $11,201 and were shipped primarily to France (99 percent). Small shipments (totaling less than 10 pounds each) were also made to West Germany, Australia, the United Kingdom, Switzerland, and Belgium-Luxembourg. Exports of uranium and thorium metals and alloys totaled 6,235 pounds (gross weight) valued at $125,686 during the year. These exports went primary to Japan (85 percent), Spain (8 percent), and Canada (5 percent).

Imports.—As indicated in table 3, imports of monazite, the only thorium ore received during the year, more than doubled and reached the highest level of the past 5-year period. The 1968 imports from Australia represented a record high for that country.

Imports of thorium metal, all from Canada, totaled 50 pounds valued at $700 in 1968. Other imports during the year included 705 pounds of thorium oxide primarily from France (99 percent) valued at $5,216, and 68 pounds of other thorium compounds valued at $9,947 from West Germany (65 percent) and Switzerland (35 percent). No imports of thorium nitrate were reported in 1968. Imports of thorium-magnesium hardeners during the year decreased approximately 53 percent. Essentially all of this material was imported from the United Kingdom. Imports of thoriated gas mantles increased during the year and totaled 3.4 million mantles valued at $329,814. These imports came from the United Kingdom (87 percent), Austria (8 percent), and West Germany (5 percent). About 1,000 mantles represent 1 pound of ThO_2.

Table 3.—U.S. imports for consumption of monazite, by countries

Country	1964		1965		1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Australia	1,450	$126	1,278	$111	1,542	$176	1,540	$195	2,810	$369
Brazil	-----	-----	64	6	-----	-----	-----	-----	-----	-----
Ceylon	335	30	141	14	-----	-----	-----	-----	-----	-----
Germany, West	-----	-----	-----	-----	-----	-----	24	4	24	4
Indonesia	-----	-----	-----	-----	-----	-----	72	13	-----	-----
Korea, South	-----	-----	22	2	-----	-----	49	7	-----	-----
Malaysia	320	30	447	50	785	92	273	38	1,514	188
Nigeria	-----	-----	76	6	-----	-----	133	13	19	2
South Africa, Republic of	-----	-----	-----	-----	115	9	-----	-----	-----	-----
Total	2,105	186	2,028	189	2,442	277	2,091	270	4,367	563
ThO_2 content [e]	130	-----	120	-----	145	-----	125	-----	262	-----

[e] Estimated.

WORLD RESERVES

A recent study of free world thorium reserves indicated no significant change from that reported previously.[3] Over half the known reserves are located in Indian placer deposits, while most of the remainder is found in veins in the United States and occurring with uranium ores in Canada. In addition, Canadian uranium ore dumps contain at least 35,000 tons of thorium oxide which, because of the lack of demand, have not been recovered. It has been estimated that total thorium reserves (assured plus possible additional) might be over 1.5 million tons of ThO_2.

Table 4.—Estimated free world resources of thorium[1]

(Thousand short tons ThO_2)

Country	Reasonably assured resources	Possible additional resources
Australia	10	---------
Brazil	10	20
Canada	80	150
Central and South America and Malagasy	50	50
Denmark (Greenland)	15	---------
India	300	250
United States	100	500
Total	565	970

[1] Cost of less than $10 per pound ThO_2.

WORLD REVIEW

Australia.—With production at an annual rate of some 3,000 tons, Australia became the world's major monazite producer in 1968. Approximately two-thirds of the country's monazite production was recovered as a byproduct of ilmenite operations in Western Australia and the balance as a byproduct of rutile mining along the east coast. Essentially all of this monazite is exported with the major portion being shipped to the United States.

The country's major monazite producer in Western Australia, Western Titanium, N.L., has an annual capacity of 1,200 tons following a recent plant expansion. In addition, Westralian Oil, N.L., which also recovers byproduct monazite from ilmenite sands, announced plans to double its monazite production to 1,500 tons annually.

Brazil.—Current monazite production in Brazil, is strictly controlled by the country's Nuclear Energy Commission Comissão Nacional de Energia Nuclear (CNEN). The only significant producer, Monazita e Ilmenita do Brasil Ltda. (MIBRA), works the beach sands in the Ponta da Fruta and Guarapari (Espirito Santo) areas. The monazite, recovered in a plant at Guarapari, is supplied to CNEN for

---

[3] Organization for Economic Co-Operation, and Development. Uranium Resources—Revised Estimates. A joint report by the European Nuclear Energy Agency, Paris, France, and the International Atomic Energy Agency, Vienna, Austria, December 1967, 25 pp.

Table 5.—Free world production of monazite concentrates, by countries[1]

(Short tons)

Country	1964	1965	1966	1967	1968[p]
Australia	2,219	2,582	[r]2,222	3,254	3,591
Brazil	733	658	822	1,189	1,864
Ceylon	25	40	40	22	46
Congo (Kinshasa)	----------	22	NA	NA	NA
India[e]	2,307	2,800	2,900	2,900	2,900
Indonesia	154	28	NA	NA	NA
Korea, South[2]	----------	28	13	14	----------
MalagasyRepublic	1,063	1,196	937	28	([3])
Malaysia (exports)	340	777	970	1,060	2,357
Nigeria[4]	11	9	8	126	7
Total[5]	6,852	8,140	7,912	8,593	10,765
ThO_2 content[e]	411	488	474	515	646

[p] Preliminary. [e] Estimate. [r] Revised. NA Not available.

[1] United States production data withheld to avoid disclosing individual company confidential data.

[2] Reported as concentrates containing 45 to 50 percent REO; also reported as 30 percent cerium, which may be high.

[3] Less than ½ unit.

[4] Year ended March 31 of year following that stated.

[5] Totals are of listed figures only.

treatment in its Orquíma plant in São Paulo which manufactures thorium salts and has capacity to process 3,000 tons of monazite annually. Currently, however, this plant is operating at less than 50 percent of its rated capacity.

CNEN itself also recovers monazite from beach sands at a small separation plant at Comoxatiba in Bahia, a few miles from Prado.

Geological surveys of Brazilian thorium and rare-earth ores were conducted which indicated that the deposit contained about one million metric tons of material with an average grade of one percent ThO_2, and four percent total REO.[4]

India.—Production of monazite from beach sands in Kerala State was increased during the year. The Alwaye plant of Indian Rare Earths Ltd. (IRE) tripled its monazite processing capacity in 1968 and can now recover 730 tons of thorium hydroxide annually. This material is all used to produce thorium nitrate and thorium oxide in a Bombay plant operated by IRE for the Indian Government.

A new separation plant set up at Manavalakurichi, Madras State, is currently recovering up to 3,000 tons of monazite annually. IRE announced plans to begin operation early in 1970 of a monazite recovery plant at Chavara, near Quilon, which will have an initial annual capacity of 600 tons.

Late in 1968 a pilot plant was commissioned for the separation and recovery of uranium-233 from thorium that had been irradiated in the Trombay nuclear reactor.

Malagasy Republic.—Production of monazite concentrates from Malagasy beach sands continued to decrease as monazite-rich deposits became exhausted and the recovery plants were closed.

Malawi.—The monazite deposits of the Kangankunde Hill carbonate complex reportedly contain relatively high REO contents but are low in thoria content. It has been estimated that this deposit contains at least 110,000 tons of low-thoria monazite.

Somali Republic.—A large ore body containing uranium, thorium, and REO was recently discovered at Alio Ghelle about 150 miles northwest of Mogadisco. Should uranium production from this ore body prove to be feasible, the deposit would represent a significant source of byproduct thorium and REO.

South Africa, Republic of.—Although current monazite production from South Africa is nil, the country has large reserves at the Steenkampskrall mine in the Van Rynsdorp District of Namaqualand.

Turkey.—A thorium deposit located 16 miles northwest of Sivrihisar is of interest because of its geological and mineralogical similarity with the Lemhi Pass thorium deposits in Idaho and Montana.

---

[4] Wedow, Jr., Helmuth. The Morro do Ferro Thorium and Rare-Earth Ore Deposit, Pocos de Caldas District, Brazil. U.S. Geological Survey Bulletin 1185–D, 1967, 36 pp.

TECHNOLOGY

A revised textbook on prospecting for radioactive minerals discussed current methods of locating and identifying thorium mineral deposits.[5] An evaluation by Bureau of Mines scientists of various extractive metallurgical procedures for recovering thorium from the Lemhi Pass deposits indicated that, except for the more stringent leaching conditions required, the optimum process and equipment needed for recovering thorium from these deposits was essentially identical with that used for recovering uranium by acid leaching and solvent extraction. Milling costs also would be comparable and any acid leach-solvent extraction uranium circuit could be readily converted to the processing of the Idaho-Montana thorium ores. Bureau metallurgists also investigated methods of electrowinning thorium to study the preparation of high-purity thorium metal from electrowon, low-melting, thorium-base alloys by vacuum distillation.

The potential of the thorium-232—uranium-233 fuel cycle in nuclear energy applications is high since the fertile thorium-232 (natural thorium) can be converted to fissionable uranium-233 by exposure to either fast or thermal neutrons.[6] Since fission in a nuclear reactor produces surplus neutrons over those required to maintain a chain reaction, it is possible to design a reactor which can produce energy and convert fertile material into fissionable fuel. These reactors are designated "Breeders" or "Converters" and are of interest because of their high burnup rates (efficiency) compared with those of enriched uranium-water cooled reactors, which have a very low fuel efficiency.

Research and development of thorium utilization in nuclear reactors was continued during the year by the AEC, its contractors, and some cooperative utilities. The AEC continued to recover uranium-233 from fuel elements irradiated in its production reactors located at Savannah River, S.C., and Richland, Wash. Five thorium-cycle converter reactor systems continued to be investigated for the AEC by scientists of the Oak Ridge National Laboratory (ORNL), Oak Ridge, Tenn.:

1. The high-temperature gas-cooled reactor (HTGR).
2. The molten-salt converter reactor experiment (MSRE).
3. The heavy-water reactor (HWR).
4. The seed blanket or light-water breeder reactor (LWBR).
5. The spectral shift control reactor (SSCR). The farthest advanced of these reactors is the HTGR system, which has been operating as a prototype at Peach Bottom, Pa. On the basis of the excellent results achieved by this reactor, a commercial 330 electrical megawatts (MWe), HTGR nuclear-power generating station is currently under construction near Platteville, Colo., by the Public Service Co. of Colorado. This system, designated the Fort St. Vrain reactor, is scheduled to become operational in 1972.

The MSRE system at ORNL was restarted during 1968 following a fuel loading of some 75 pounds of uranium-233 and became the world's first reactor to operate completely on this manmade nuclear fuel.[7] Advantages of this reactor system include high operating temperature, high neutron utilization, continuous gaseous fission-product removal, no need for fuel element fabrication, low fuel-cycle costs, and a fluid fuel which can be more easily reprocessed than can solid fuels.[8]

Investigations of the physical, mechanical, and irradiation properties of thorium metal and alloys were reported and the thorium fuel cycle was described and analyzed in detail during the year.[9]

Studies of thoria-strengthened nickel, cobalt, and molybdenum alloys indicated that optimum dispersion strengthening and creep resistance occurred in alloys with thoria concentrations of 2 percent.[10]

---

[5] Bureau of Mines. Prospecting and Exploring for Radioactive Minerals: Supplement to Facts Concerning Uranium Exploration and Production. Inf. Circ. 8396, 1968, 36 pp.

[6] Chemical Engineering. Meeting the World's Voracious Appetite for Energy. V. 76, No. 1, Jan. 13, 1969, pp. 101–102.

[7] U.S. Atomic Energy Commission. News release L–236. Oct. 8, 1968, 3 pp.

Chemical Engineering. V. 75, No. 23, Oct. 21, 1968, p. 48.

[8] Chemical Week. V. 103, No. 21, Nov. 23, 1968, p. 56.

[9] Simmonds, E. M., S. W. Porembka, Jr., and D. L. Keller. Reactor Materials. V. 11, Nos. 1–4, 1968, 283 pp

[10] Wagner, H. J., W. F. Simmons, and V. F. Beuhring. DMIC Review of Recent Developments: Nickel- and Cobalt-Base Alloys. Defense Metals Inf. Center, Battelle Memorial Inst., Columbus, Ohio, Aug. 9, 1968, 5 pp.

Wilcox, B. A., A. H. Clauer, and W. S. McCain. Creep and Creep Fracture of Ni–20Cr–2ThO$_2$ Alloy. Trans. of Met. Soc. AIME, v. 239, No. 11, November 1967, pp. 1791–1795.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/183

Tin

By John R. Lewis[1]

The United States continued to lead the world in tin usage in 1968. A total of 81,961 long tons was consumed, of which 58,859 long tons (mostly imported) was as primary tin metal. The United States outdistances the other tin-using nations in use of secondary (i.e. reclaimed) tin, consuming 23,102 long tons in 1968. Total tin consumed was slightly more than in the previous year but still about 4.1 percent below the peak of 1966.

The International Tin Council met four times during 1968, three times in London and once in La Paz, Bolivia. Heading the list of actions taken was notation by the Council of the persistent weakness in the tin market reflecting itself in prices, and an agreement on September 18, 1968, by producing member nations to limit tin exports for the remainder of calendar year 1968 to a rate equivalent to 38,000 long tons per calendar quarter. Prices firmed late in the year, especially in the United States where users made heavy hedge purchases against the expected dock strike.

Except for a small amount of Far East tin entering the country via California ports, nearly all tin arriving in the United States came in through east coast ports. East and gulf coast ports were struck by dockworkers and closed from December 20, 1968, to February 17, 1969. Tin buyers had purchased heavily during the second half of 1968 in anticipation of the strike and by yearend 1968, U.S. warehouses were well supplied, and no dislocations had yet appeared. Smaller tin users, however, apparently began to suffer before the strike was over.

Legislation and Government Programs.—There was no legislation directly affecting tin during 1968.

On July 1, 1968, the General Services Administration (GSA) announced that it was suspending commercial sales of tin pending results of a government review of methods of disposing of excess tin. GSA

Table 1.—Salient tin statistics

(Long tons)

	1964	1965	1966	1967	1968
United States:					
Production:					
Mine	65	47	97	W	W
Smelter	W	3,098	3,825	3,048	3,453
Secondary	23,508	25,076	25,849	22,667	22,495
Exports (exports and reexports)	4,041	2,829	2,847	2,479	4,495
Imports for consumption:					
Metal	32,132	40,816	41,699	50,223	57,358
Ore (tin content)	5,190	4,236	4,372	3,255	2,282
Consumption:					
Primary	58,543	58,505	60,185	57,848	58,859
Secondary	24,304	25,461	25,277	22,790	23,102
Price: Straits tin, in New York, average cents per pound	157.72	178.17	164.02	153.405	148.111
World: Production:					
Mine	193,457	201,115	208,071	215,006	226,624
Smelter	191,080	197,181	200,502	219,276	230,021

W Withheld to avoid disclosing individual company confidential data.

---

[1] Commodity specialist, Division of Mineral Studies.

stated, however, that sales under the program of the Agency for International Development would continue during the period of review. The announcement also promised that no significant change in the tin disposal program would be put into effect without appropriate consultations. On September 27, 1968, a followup announcement by GSA revealed that the review had not been completed, that no significant change in the tin disposal program would be put into effect until after appropriate consultations, and that in the interim the GSA would not sell tin commercially. There was no further announcement by yearend.

DOMESTIC PRODUCTION

MINE PRODUCTION

Very little tin ore has been mined in the United States over the past decade, and little change is expected. Almost half of the small amount recovered in 1968 came as a byproduct of molybdenum mining in Colorado, while the remainder was mined in Alaska and California. In all, less than 100 long tons of tin metal was mined.

SMELTER PRODUCTION

The United States' only tin smelter, located at Texas City, Tex., was sold by Wah Chang Corp., a subsidiary of Teledyne, Inc. on September 1, 1968, to Fred H. Lenway & Co., Inc., San Francisco, Calif. The smelter has been producing refined tin pigs which are 99.96 percent Sn, primarily from low-grade Bolivian concentrates (19 percent Sn) by an electrolytic process.

The Texas City smelter produced 3,453 long tons of tin in 1968, compared with 3,048 long tons in 1967. Practically all of the tin produced for several years, including 1968, was consumed in tinplate manufacturing plants in Chicago, Ill., Fairfield, Ala., and Pittsburgh, Pa.

SECONDARY TIN

About 30 percent of the tin consumed in the United States in 1968 was recovered from secondary sources. Some 85 percent was recovered as alloys, either from copper base scrap in smelters or foundries or from lead or tin base scrap. In the latter group are solders, type metal, babbitt, drosses, and other residues. The balance

Table 2.—Secondary tin recovered from scrap processed at detinning plants in the United States

	1967	1968
Tinplate scrap treated [1] long tons	773,605	778,346
Tin recovered in the form of—		
Metal long tons	2,667	2,447
Compounds (tin content) long tons	486	492
Total [2] do	3,153	2,939
Weight of tin compounds produced long tons	940	893
Average quantity of tin recovered per long ton of tinplate scrap used pounds	9.13	8.46
Average delivered cost of tinplate scrap per long ton	$24.18	$21.58

[1] Tinplate clippings and old tin-coated containers have been combined to avoid disclosing individual company confidential data.

[2] Recovery from tinplate scrap treated only. In addition, detinners recovered 400 long tons (293 tons in 1967) of tin as metal and in compounds from tin-base scrap and residues in 1968.

Table 3.—Tin recovered from scrap processed in the United States,

(Long tons)

Form of recovery	1967	1968
Tin metal:		
At detinning plants	2,939	2,815
At other plants	237	163
Total	3,176	2,978
Bronze and brass:		
From copper-base scrap	10,952	11,624
From lead and tin-base scrap	316	271
Total	11,268	11,895
Solder	4,775	4,215
Type metal	1,604	1,604
Babbitt	912	838
Antimonial lead	386	400
Chemical compounds	506	524
Miscellaneous [1]	40	41
Total	8,223	7,622
Grand total	22,667	22,495
Value (thousands)	$77,893	$74,631

[1] Includes foil, cable lead and terne metal.

of recovered tin was obtained as tin metal from detinning plants, most of which use an alkali chemical process to strip the tinplating from cans and scrap.

Secondary tin metal (as differentiated from tin recovered in alloys) was recovered to a greater degree in the United States in 1968 than anywhere else in the world. Detailed data on these recoveries have not been kept except in the United States, but the International Tin Council estimated that four nations used 77 percent of the world's secondary tin metal in 1968 as follows: United States (35 percent), United Kingdom (23 percent), West Germany (11 percent), and Austria (8 percent).[2]

CONSUMPTION

Primary and secondary tin consumption in the United States showed a 1.6 percent improvement in 1968, thereby reversing, but not eradicating, the 6-percent dip experienced in 1967. U.S. consumption of both primary and secondary tin was 81,961 long tons in 1968, compared with 80,638 long tons in 1967 and 85,462 long tons in 1966. Primary tin consumption rose 1.7 percent in 1968 over that of 1967 while secondary tin consumption improved only 1.4 percent.

Tin faced severe competition, in 1968, from glass, aluminum, tin-free steel, and plastics, especially in the container field. However, increased use of solder for electronic devices, vigorous activity among bronze and brass makers, a strike in the glass bottle industry, an unusually heavy food pack, and increasing use of tin in a molten float bath for making large plates of very smooth glass proved helpful in improving demand.

Table 4.—Shipments of metal cans[1]

(Thousand base boxes)

Type of can	1967 [r]	1968	1968 change, percent
FOOD AND BEVERAGES			
Fruit and fruit juices	14,313	14,315	------
Vegetables and vegetable juices	21,952	24,540	+11.8
Milk, evaporated and condensed	3,337	2,854	−14.5
Other dairy products	728	731	+.4
Soft drinks	14,580	20,050	+37.5
Beer	27,537	30,787	+11.8
Meat and poultry	3,803	3,919	+3.0
Fish and other seafoods	2,920	2,833	−3.0
Coffee	4,162	4,117	−1.1
Lard and shortening	1,986	1,695	−17.7
Baby foods	855	862	+.8
Pet foods	5,797	6,200	+7.0
All other foods, including soups	13,227	13,510	+2.1
Total or average	115,197	126,413	+19.7
NONFOOD			
Oil	3,056	3,166	+.4
Paint and varnish	4,154	4,393	+5.8
Antifreeze	828	923	+11.5
Pressure packing (valve type)	4,371	4,751	+8.7
All other nonfood	6,374	6,454	+1.3
Total or average	18,783	19,687	+4.8
BY METAL			
Steel base boxes	126,141	136,226	+8.0
Short tons (thousand)	5,149	5,560	+8.0
Aluminum base boxes	7,839	9,810	+25.1
Short tons (thousand)	174	209	+20.1

[r] Revised.

[1] Includes both tinplate and aluminum cans.

Sources: U.S. Department of Commerce; The Malayan Tin Bureau.

---

[2] International Tin Council. Statistical Bulletin, March 1969, p. 41, table G–3.

Table 5.—Stocks, receipts and consumption of new and old scrap and tin recovered in the United States in 1968

(Long tons)

Type of scrap and class of consumer	Gross weight of scrap						Tin recovered		
	Stocks Jan. 1	Receipts	Consumption			Stocks Dec. 31			
			New	Old	Total		New	Old	Total
Copper-base scrap:									
Secondary smelters:									
Auto radiators (unsweated)	2,879	51,666	------	51,487	51,487	3,058	-----	2,214	2,214
Brass, composition or red	4,779	80,039	16,897	64,173	81,070	3,748	642	2,387	3,029
Brass, low (silicon bronze)	478	4,801	3,863	895	4,758	521	-----	5	5
Brass, yellow	6,452	57,380	8,198	50,526	58,724	5,108	24	466	490
Bronze	3,038	28,757	4,451	24,797	29,248	2,547	350	1,951	2,301
Low-grade scrap and residues	6,083	54,294	43,473	8,459	51,932	8,445	16	-----	16
Nickel silver	863	4,544	638	4,177	4,815	592	5	32	37
Railroad-car boxes	186	1,625	------	1,648	1,648	163	-----	78	78
Total	24,758	283,106	77,520	206,162	283,682	24,182	1,037	7,133	8,170
Brass mills:[1]									
Brass, low (silicon bronze)	5,239	35,571	35,571	------	35,571	3,082	-----	-----	-----
Brass, yellow	24,119	231,258	231,258	------	231,258	16,904	298	-----	298
Bronze	929	3,792	3,792	------	3,792	652	184	-----	184
Mixed alloy scrap	[r] 6,331	2,143	2,143	------	2,143	3,134	2	-----	2
Nickel silver	8,498	10,931	10,931	------	10,931	6,298	-----	-----	-----
Total	[r] 45,116	283,695	283,695	------	283,695	30,070	484	-----	484
Foundries and other plants:[2]									
Auto radiators (unsweated)	1,358	5,524	------	6,007	6,007	870	-----	270	270
Brass, composition or red	571	4,179	1,495	2,648	4,143	607	71	126	197
Brass, low (silicon bronze)	111	408	246	244	490	29	-----	2	2
Brass, yellow	889	6,058	2,995	3,285	6,280	667	6	26	32
Bronze	442	1,575	547	999	1,546	471	49	78	127
Low-grade scrap and residues	2,488	10,655	3,377	7,289	10,666	2,477	-----	-----	-----
Nickel silver	4	63	19	44	63	4	-----	-----	-----
Railroad-car boxes	1,637	21,826	------	22,287	22,287	1,176	-----	1,059	1,059
Total	7,495	50,288	8,679	42,803	51,482	6,301	126	1,561	1,687
Total tin from copper-base scrap	------	------	------	------	------	-----	1,647	8,694	10,341
Lead-base scrap:									
Smelters, refiners, and others:									
Babbitt	372	10,404	------	10,413	10,413	363	-----	505	505
Battery lead plates	25,698	412,205	------	414,326	414,326	23,577	-----	435	435
Drosses and residues	[r] 17,724	96,051	92,829	------	92,829	20,946	1,937	-----	1,937
Solder and tinny lead	249	10,136	------	10,183	10,183	202	-----	1,778	1,778
Type metals	3,217	31,129	------	31,294	31,294	3,052	-----	1,487	1,487
Total	[r] 47,260	559,925	92,829	466,216	559,045	48,140	1,937	4,205	6,142
Tin-base scrap:									
Smelters, refiners, and others:									
Babbitt	31	390	9	378	387	34	7	317	324
Block-tin pipe	4	217	------	203	203	18	-----	201	201
Drosses and residues	[r] 878	3,618	4,044	------	4,044	452	2,138	-----	2,138
Pewter	1	14	------	12	12	3	-----	10	10
Total	914	4,239	4,053	593	4,646	507	2,145	528	2,673
Tinplate scrap:									
Detinning plants	------	------	778,346	------	778,346	-----	3,339	-----	3,339
Grand total	------	------	------	------	------	-----	9,068	13,427	22,495

[r] Revised.

[1] Lines in brass mills and total sections do not balance as stocks include home scrap—purchased scrap assumed to equal receipts.

[2] Omits "machine shop scrap."

Table 6.—Consumption of primary and secondary tin in the United States

(Long tons)

	1964	1965	1966	1967	1968
Stocks Jan. 1 [1]	29,548	32,591	37,277	32,718	30,087
Net receipts during year:					
Primary	62,939	64,302	56,869	[r] 56,324	58,870
Secondary	2,524	2,530	2,713	2,884	2,101
Scrap	22,985	24,676	23,654	21,492	21,693
Total	88,448	91,508	83,236	[r] 80,700	82,664
Available	117,996	124,099	120,513	[r] 113,418	112,751
Stocks Dec. 31 [1]	32,591	37,277	32,718	[r] 30,087	27,778
Total processed during year	85,405	86,822	87,795	83,331	84,973
Intercompany transactions in scrap	[r] 2,558	[r] 2,856	[r] 2,333	[r] 2,693	3,012
Tin consumed in manufactured products	[r] 82,847	[r] 83,966	[r] 85,462	[r] 80,638	81,961
Primary	[r] 58,543	[r] 58,505	[r] 60,185	57,848	58,859
Secondary	24,304	25,461	25,277	22,790	23,102

[r] Revised.

[1] Stocks shown exclude tin in transit or in other warehouses on Jan. 1, as follows: 1964, 175 tons; 1965, 220 tons; 1966, 135 tons; 1967, 90 tons; 1968, 20 tons; and 1969, 1,185 tons.

Table 7.—Tin content of tinplate produced in the United States

Year	Tinplate (hot dipped)			Tinplate (electrolytic)			Tinplate waste—waste, strips, cobbles, etc., gross weight (short tons)	Total tinplate (all forms)		
	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)	Gross weight (short tons)	Tin content (long tons)	Tin per short ton of plate (pounds)		Gross weight (short tons)	Tin content (long tons) [1]	Tin per short ton of plate (pounds)
1964	138,178	[r] 1,341	[r] 21.7	5,204,541	[r] 29,835	[r] 12.8	637,481	5,980,200	[r] 31,176	11.7
1965	80,645	914	25.4	5,245,642	[r] 29,105	[r] 12.4	599,400	5,925,687	[r] 30,019	[r] 11.3
1966	42,290	366	[r] 19.4	5,154,550	[r] 28,194	12.3	675,558	[r] 5,872,398	[r] 28,560	[r] 10.9
1967	[r] 26,612	[r] 263	[r] 22.2	5,544,987	[r] 29,289	[r] 11.9	[r] 743,689	[r] 6,315,288	[r] 29,552	10.5
1968	(2)	(2)	(2)	(2)	(2)	(2)	682,792	6,088,345	28,839	10.6

[r] Revised.

[1] Includes small tonnage of secondary tin and tin acquired in chemicals.

[2] Hot-dipped and electrolytic tinplate have been combined to avoid disclosing individual company confidential data.

Table 8.—Consumers receipts of primary tin, by brands

(Long tons)

Year	Banka	English	Katanga	Straits	Thaisarco	Others	Total
1964	1,271	1,441	1,839	38,972	--------	[1] 19,416	62,939
1965	3,112	425	850	38,434	1,950	[1] 19,531	64,302
1966	709	433	95	30,560	9,815	[1] 15,257	56,869
1967	404	704	91	31,980	13,400	[1] [r] 9,745	[r] 56,324
1968	305	950	12	40,900	11,600	5,103	58,870

[1] Includes GSA not reported under specific brands.

Table 9.—Consumption of tin in the United States, by finished products

(Long tons of contained tin)

	1967			1968		
	Primary	Secondary	Total	Primary	Secondary	Total
Alloys (miscellaneous)	310	142	452	442	182	624
Babbitt	1,662	1,159	2,821	2,143	1,440	3,583
Bar tin	854	21	875	970	115	1,085
Bronze and brass	4,350	12,110	16,460	3,851	11,631	15,482
Chemicals including tin oxide	937	1,837	2,774	1,744	1,423	3,167
Collapsible tubes and foil	1,071	38	1,109	1,114	55	1,169
Pipe and tubing	53	14	67	53	37	90
Solder	14,052	6,070	20,122	14,685	6,685	21,370
Terne metal	264	179	443	295	185	480
Tinning	2,551	58	2,609	2,105	55	2,160
Tinplate [1]	r 29,552	--------	r 29,552	28,839	--------	28,839
Tin powder	924	19	943	1,103	53	1,156
Type metal	100	1,019	1,119	108	1,109	1,217
White metal [2]	1,094	70	1,164	1,330	66	1,396
Other	74	54	128	77	66	143
Total	r 57,848	22,790	r 80,638	58,859	23,102	81,961

r Revised.

[1] Includes secondary pig tin and tin acquired in chemicals.

[2] Includes britannia metal, jewelers' metal, and pewter.

STOCKS

Tin stocks on hand in, or en route to, the United States as of December 31, 1968, continued a 4-year decline, although the reduction noted between 1968 and 1967 was not quite as sharp as had occurred in earlier years. One factor which probably contributed to the reduced grand totals of U.S. tin stocks were the export controls imposed for the last 104 days of 1968 upon producing member nations of the International Tin Council.

The strike of longshoremen at east and gulf coast ports was still underway at yearend, and ships were known to be in certain east coast ports waiting to unload pig tin. The unusually high amount of tin reported in table 10 as "afloat to the United States" reflects the magnitude of this backlog. During the summer of 1968, tin buying and coastal warehouse tin receipts were considerably inflated in anticipation of the dockworkers' strike and by yearend, warehouses still were shipping tin to consumers in the interior.

Table 10.—U.S. industry tin stocks

(Long tons)

	1964	1965	1966	1967	1968
Plant raw materials:					
Pig tin:					
Virgin	20,926	25,319	20,531	17,044	15,952
Secondary	247	202	276	283	215
In process [1]	11,418	11,756	11,911	r 12,760	11,611
Total	32,591	37,277	32,718	r 30,087	27,778
Additional pig tin:					
In transit in United States	220	135	90	20	1,185
Jobbers-importers	[2] 2,950	[3] 2,000	[4] 1,790	[5] 1,315	1,182
Afloat to United States	1,740	1,875	3,415	4,890	5,390
Total	4,910	4,010	5,295	6,225	7,757
Grand total	37,501	41,287	38,013	r 36,312	35,535

r Revised.

[1] Tin content, including scrap.

[2] Includes GSA as follows: 1,590 tons end of December 1964, sold but not delivered.

[3] Includes GSA as follows: 975 tons end of December 1965, sold but not delivered.

[4] Includes GSA as follows: 1,539 tons end of December 1966, sold but not delivered.

[5] Includes GSA as follows: 428 tons end of December 1967, sold but not delivered.

PRICES

Prices for top-graded Straits tin delivered in New York City began the year 1968 on a downhill trend which had started during the summer of 1967, at which time prices for this tin in New York were around $1.55 per pound. One year later, between June and August 1968, this price bottomed out at around $1.42 per pound, the lowest monthly average Straits-New York delivered price since May 1964. The rapid acceleration which began in September 1968 could be traced to several overlapping conditions. Hedge buying against the possibility of a longshoremen's strike drove prices to a high of $1.68 on December 6, shortly before the strike finally materialized on December 20. There was also a certain price strength which could be identified with the export controls imposed by the International Tin Council on September 19, and with continued suspension of tin sales from the strategic stockpile by the U.S. Government. The fractional amounts of grade A tin that moved into commercial channels from the U.S. stockpile early in 1968 all was sold at an average quotation of $1.54 per pound.

Table 11.—Monthly prices of Straits tin for prompt delivery in New York

(Cents per pound)

Month	1967			1968		
	High	Low	Average	High	Low	Average
January	154.125	153.125	153.881	150.750	144.750	147.875
February	155.000	153.875	154.382	145.750	145.000	145.632
March	154.250	153.000	153.710	147.000	145.250	145.625
April	154.250	152.750	153.331	145.750	144.500	145.214
May	154.500	152.250	153.114	144.500	142.750	143.295
June	157.000	152.750	154.943	142.250	141.250	141.650
July	155.000	153.375	154.394	142.250	141.000	141.477
August	153.375	151.875	152.500	142.500	141.500	141.852
September	151.875	150.750	151.013	152.000	142.500	148.038
October	153.500	150.625	151.994	157.250	148.250	151.071
November	156.000	154.000	155.013	167.250	157.750	162.139
December	154.000	151.250	152.588	167.750	159.000	163.464
Average	157.000	150.625	153.405	167.750	141.000	148.111

Source: American Metal Market.

FOREIGN TRADE

Because the United States produces only a very small amount of tin, its imports of tin metal dominate the Nation's tin trade. Of the tin imported in 1968, 72 percent came from Malaysia and 21.5 percent from Thailand, while another 2.4 percent was received from the United Kingdom. Imports of tin in concentrates fell about

Table 12.—U.S. exports and imports for consumption of tin, tinplate, and terneplate in various forms

Year	Ingots, pigs, and bars				Tinplate and terneplate				Tinplate circles, strips, and cobbles		Tinplate scrap	
	Exports		Reexports		Exports		Imports		Exports		Imports	
	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)	Long tons	Value (thousands)
1966	1,866	$6,985	981	$3,849	257,140	$41,746	111,678	$22,096	11,031	$1,229	14,687	$535
1967	2,050	6,962	429	1,412	241,873	39,781	139,598	27,112	13,732	1,485	12,078	381
1968	3,813	12,734	682	2,267	249,392	41,898	203,269	39,156	13,631	1,405	15,827	541

Table 13.—U.S. imports for consumption and exports of miscellaneous tin, tin manufactures, and tin compounds

Year	Miscellaneous tin manufactures				Tin compounds	
	Imports			Exports	Imports	
	Tinfoil, tin powder, flitters, metallics, tin, and manufactures n.s.p.f., value (thousands)	Dross, skimmings, scrap, residues, and tin alloys n.s.p.f.		Tin scrap and other tin-bearing material except tinplate scrap		
		Long tons	Value (thousands)	Value (thousands)	Long tons	Value (thousands)
1966	$251	108	$124	$1,957	295	$476
1967	355	449	462	1,490	81	208
1968	2,742	487	532	2,676	89	81

Table 14.—U.S. imports for consumption of tin,[1] by countries

Country	1967		1968	
	Long tons	Value (thousands)	Long tons	Value (thousands)
Belgium-Luxembourg	228	$777	12	$37
Bolivia	571	1,961	38	100
Canada	1	41	1	11
Chile	73	238	------	-------
Germany, West	80	263	------	-------
India	10	33	------	-----
Indonesia	129	420	350	1,134
Malaysia	30,691	101,802	41,324	131,738
Netherlands	25	83	871	2,652
Nigeria	-----	-------	606	1,933
Peru	159	529	------	-------
Portugal	275	920	240	776
Singapore	62	217	80	246
South Africa, Republic of	-----	-------	50	158
Spain	-----	-------	30	94
Thailand	16,586	54,786	12,326	38,199
United Kingdom	1,333	4,459	1,430	4,862
Total	50,223	166,529	57,358	181,940

[1] Bars, blocks, pigs, grain, or granulated.

Table 15.—U.S. imports for consumption of tin concentrate, by countries

Country	1967		1968	
	Long tons (tin content)	Value (thousands)	Long tons (tin content)	Value (thousands)
Australia	------	------	96	$86
Bolivia	3,247	$7,608	2,180	5,284
Congo (Kinshasa)	------	------	6	17
Peru [1]	7	24	------	------
United Kingdom	1	8	------	------
Total	3,255	7,685	2,282	5,287

[1] Reported by the Bureau of the Census as coming from Peru, but believed by the Bureau of Mines to be from Bolivia.

30 percent in 1968, to 2,282 long tons. As the Nation's only tin smelter began phasing itself out of the tin business when its supply arrangement with Bolivia expired, so too did Bolivian concentrates shipped to the United States begin to dwindle. By yearend the concentrate importing operation essentially had ceased.

Significant quantities of various tin semimanufactures and manufactures continued to be exported in 1968. That tin which is contained in imports and exports of babbitt, solder, type metal, and bronze is shown in the Copper and Lead Yearbook chapters. Ferrous scrap exports, including tinplate and terneplate scrap, are not classified separately.

WORLD REVIEW

INTERNATIONAL TIN AGREEMENT

Three successive 5-year International Tin Agreements have served, since July 1, 1956, to regulate certain segments of the world's tin trade. The Third International Tin Agreement became effective July 1, 1966, and continues to June 30, 1971. A fourth and continuing 5-year agreement was under preliminary study as 1968 drew to a close. The United States, West Germany and the U.S.S.R., all large tin consumers, are not members.

The agreements are administered from the London headquarters of the International Tin Council (ITC). Voting rights of the producing member nations are based upon the amounts of tin each produces. Total producing votes equal 1,000. Likewise, the voting rights (1,000 in all) of the consuming member nations are based upon the amounts of tin which each consumes. Thus, each group has an equal number of votes in the Council.

The ITC held four meetings in 1968:

Meeting number: (under Third IT Agreement)	Dates	Place
7	January 16–18	London, England
8	April 22–24	La Paz, Bolivia
9	September 17–19	London, England
10	December 17–19	London, England

During the September meeting, votes of producing member nations were adjusted slightly and agreed to as follows:

Producing member country	Votes effective Sept. 17, 1968
Bolivia	179
Congo (Kinshasa)	51
Indonesia	98
Malaysia	450
Nigeria	70
Thailand	152
Total	1,000

In October 1967, Israel joined the 16 other consuming nation members. Votes of the consuming countries were then adjusted as follows:

Consuming member country	Total votes Jan. 16 to June 30, 1968 and to June 30, 1969 [1]
Australia	55
Austria	12
Belgium	37
Canada	61
Czechoslovakia	38
Denmark	11
France	124
India	48
Israel [2]	6
Italy	71
Japan	208
Korea	9
Mexico	19
Netherlands	42
Spain	25
Turkey	14
United Kingdom	220
Total	1,000

[1] These votes were confirmed at the April 1968 meeting to be the votes for the full year beginning July 1, 1968.

[2] Recognized officially during January 1968 meeting of ITC.

ITC buffer stock holdings of tin metal were as follows:

As of	Long tons
January 18, 1968	7,165
March 31, 1968	8,225
June 30, 1968	9,200
September 18, 1968	11,290

At its September meeting the ITC noted persistent weakness in the tin market which had reflected itself in prices and accordingly, under terms of the agreement, the Council declared the imposition of the first period of export control in slightly more than 10 years. The 104 days from September 19 to December 31 were designated as a period of export control and a total export equivalent to 38,000 long tons per calendar quarter was established, broken down for each producing country as follows:

Producing country	Tin metal (long tons)	
	104 days' export	Calendar 4th quarter equivalent
Bolivia	7,505	6,640
Congo (Kinshasa)	1,994	1,764
Indonesia	4,040	3,575
Malaysia	20,255	17,920
Nigeria	2,812	2,488
Thailand	6,344	5,613
Total	42,950	38,000

After consideration of all factors involved, the Council, at its December meeting, declared a second period of export control for the first calendar quarter of 1969. Amounts exportable were to be equivalent to those for the fourth quarter of 1968. These cutbacks amounted to about 3¾ to 4 percent on an annual basis of 152,000 long tons. Tin miners in Thailand were reported to have protested the cutbacks because of mine closings and unemployment. Other small pockets of mild protest by miners occurred in Malaysia.

Other important actions agreed upon by the ITC during 1968 included, with minor amendments, these tin purchase price ranges (in pounds sterling per long ton):

Floor	Lower sector	Middle sector	Upper sector	Ceiling
1,280	1,280 to 1,400	1,400 to 1,515	1,515 to 1,630	1,630

Also, at the December meeting the Council noted with appreciation that the Australian Government had decided to introduce export controls upon tin and tin concentrate produced in Australia for the fourth quarter of 1968 and encouraged similar action by Australia in the first quarter of 1969.

Australia.—Tin mining was being carried out in 1968 by some 25 separate companies in six of Australia's seven States. Tasmania led with slightly over 2,000 long tons of tin metal equivalent produced. Queensland and New South Wales were not far behind with about 1,500 tons each. Australia's tin production first exceeded her domestic demand in 1966. By 1967 there was a net export of around 1,000 tons of tin metal (most of the nation's concentrates are smelted domestically) and indications were that there would be an exportable surplus by 1969 of around 4,500 tons, at which level the surplus appeared likely to stabilize. In 1968 there were small amounts of Australian tin concentrates moving to Japan and to a Japanese-controlled smelter in Malaysia. There were

Table 16.—World mine production of tin (content of ore), by countries[1]

(Long tons)

Country [2]	1964	1965	1966	1967	1968 p
North America:					
Canada	157	168	317	237	150
Mexico	r 1,206	503	r 789	588	519
United States	65	47	97	W	W
South America:					
Argentina	343	497	458	p 802	NA
Bolivia [3]	24,319	23,036	25,626	26,890	28,576
Brazil	790	1,810	r 1,599	1,866	e 2,200
Peru (recoverable)	36	49	37	78	94
Europe:					
Czechoslovakia	r NA	r NA	[5] 148	150	e 155
France	486	447	r 421	450	e 475
Germany, East [4]	1,000	1,000	1,000	1,000	1,000
Portugal [5]	676	557	600	645	e 650
Spain	91	111	r 200	113	118
U.S.S.R.[6,7]	22,000	23,000	24,000	25,000	26,000
United Kingdom	1,226	1,313	1,272	1,475	1,798
Africa:					
Burundi	r 14	r 17	r 50	45	98
Cameroon	40	40	45	50	NA
Congo (Brazzaville)	34	44	48	48	NA
Congo (Kinshasa)	5,108	6,324	5,036	4,664	6,470
Morocco	14	r 15	r 11	10	19
Niger	48	53	r 86	80	102
Nigeria	8,721	9,547	9,354	9,340	9,644
Rhodesia, Southern	512	510	600	e 600	NA
Rwanda	1,360	1,424	r 885	1,929	1,719
South Africa, Republic of	1,586	1,671	r 1,745	1,761	e 1,800
South-West Africa, Territory of	474	416	664	e 720	e 700
Swaziland	3	2	1	1	---------
Tanzania	287	255	353	341	440
Uganda	217	178	122	111	163
Zambia	8	16	3	---------	-------
Asia:					
Burma [5]	916	677	r 377	466	314
China, mainland [6]	25,000	25,000	22,000	20,000	20,000
Indonesia	16,345	14,699	12,526	13,597	16,563
Japan	796	837	971	1,166	943
Korea, South	---------	r 2	32	40	44
Laos	336	284	e 340	533	e 500
Malaysia	60,004	63,670	68,886	72,121	75,069
Thailand	15,597	19,047	22,565	22,489	23,678
Oceania: Australia	3,642	3,849	r 4,807	5,600	6,623
Total [8]	r 193,457	r 201,115	r 208,071	215,006	226,624

e Estimate. p Preliminary. r Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Data derived in part from the Statistical Bulletin of the International Tin Council, London, England.

[2] Negligible amounts of tin were also produced in Mozambique and Surinam during 1964–68.

[3] Comibol production plus exports by small and medium mines and smelters.

[4] Estimate, according to the 55th annual issue of Metal Statistics (Metallgesellschaft) through 1967.

[5] Includes tin content of mixed concentrates.

[6] Estimated smelter production.

[7] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[8] Total is of listed figures only.

Table 17.—World smelter production of tin, by countries[1]

(Long tons)

Country	1964	1965	1966	1967	1968 [p]
North America:					
Mexico	1,145	459	795	607	317
United States [2] [3]	5,190	3,098	3,825	3,048	3,453
South America:					
Bolivia	3,610	3,415	1,062	800	[e] 60
Brazil	1,731	1,753	[r] 1,211	1,415	1,251
Europe:					
Belgium	5,458	4,232	[r] 4,973	4,193	4,799
Germany:					
East [4]	1,200	1,200	1,200	1,200	1,200
West	1,178	1,427	1,362	1,622	1,502
Netherlands	15,858	18,114	12,552	13,739	7,983
Portugal	589	603	556	592	[e] 630
Spain	1,774	1,787	[r] 1,877	1,823	2,169
U.S.S.R.[e] [5]	22,000	23,000	24,000	25,000	26,000
United Kingdom	16,849	16,494	17,499	23,317	24,933
Africa:					
Congo (Kinshasa)	1,485	1,815	2,002	1,815	1,800
Morocco [e]	10	12	12	12	15
Nigeria [6]	8,749	9,321	9,869	9,131	9,778
Rhodesia, Southern	511	494	[e] 480	[e] 600	NA
South Africa, Republic of	1,016	962	822	659	686
Asia:					
China, mainland [e]	25,000	25,000	22,000	20,000	20,000
Indonesia	[r] 1,363	[r] 1,189	[r] 822	1,481	4,885
Japan	1,954	1,610	1,836	1,666	1,888
Malaysia	71,351	72,469	71,045	76,828	88,318
Thailand	38	[r] 5,548	[r] 17,062	26,634	24,662
Oceania: Australia	3,021	3,179	3,640	3,594	3,692
Total [7]	[r] 191,080	[r] 197,181	[r] 200,502	219,276	230,021

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Data derived in part from the Statistical Bulletin of the International Tin Council, London, England.

[2] Includes tin content of alloys made directly from ores.

[3] Imports into the United States of tin concentrates (tin content).

[4] Estimate, according to the 55th annual issue of Metal Statistics (Metallgesellschaft) through 1967.

[5] Output from U.S.S.R. in Asia included with U.S.S.R. in Europe.

[6] Including a small amount smelted from imported concentrates.

[7] Total is of listed figures only.

two smelters in the country: M & T. Chemicals (Australian) Pty. Ltd. at Sidney and the Associated Tin Smelters Pty. Ltd., in Alexandria, both in New South Wales.

Meanwhile, exploration and development work was proceeding at all major prospects. Again, the hub of activity was in Tasmania and offshore in the Bass Straits between Tasmania and New South Wales. This latter project was being undertaken by Ocean Mining A.G., an exploration affiliate of Ocean Science and Engineering Inc. and the Anglo American Group.

Full operational status of the Mount Cleveland mine at Luina, in northwestern Tasmania, was achieved about mid-1968. This entire project was under operational responsibility of Aberfoyle Tin N.L. and was expected to produce 250,000 tons of tin and copper ore per year for at least 5 years and probably a great many more. A treatment plant and a mine community were also ready. Estimated capital outlay to bring the mine to production was around $9.14 (A$8.6) million. Tin concentrates were slated to go to the Sydney smelters. Development of the newest Mount Cleveland ore bodies, part of a long-known and several-times-worked deposit, was said to be traceable to the firm tin prices of the early 1960's.

There was vigorous development activity beyond the confines of Tasmania, in northern Queensland around Irvine Bank; in Victoria at the Walwa tinbearing areas; at Gibsonvale, New South Wales; and in Western Australia near Perth.

Bolivia.—The tin dredging operation of the Estalsa consortium, of which W. R. Grace & Co. is a member, was declared a technical and financial success in 1968. Located on the Bolivian antiplano about 150 miles south of La Paz at an elevation of 13,000 feet, the operation is the only tin-dredging project in the Western Hemisphere. The 2,500 ton Uba dredge, which once dredged gold near Hammonton, Calif., was dismantled and moved in component pieces by ship and rail to its present remote site. It operates in the alluvial deposits emerging from the canyon of the Avicaya River, and also in the water sorted glacial moraine of an adjacent hillside. After considerable modification and adaption work, the dredge now works deposits buried under coarse gravels which were previously inaccessible. Its 14-cubic-foot buckets will dig as deep as 110 feet below the surface of the riverbed. The unit can handle 15,000 tons of raw gravel per day.

Work proceeded on schedule at the Empresa Nacional de Fundiciones (ENAF) smelter and refinery site near Oruro during 1968. The West German Kloeckner group were delivering the metal structures and machinery and all indications persisted that the first stage of the smelter would probably be operable toward the end of 1969. Eventually, annual output of 20,000 metric tons of high-grade tin metal is planned, but at the outset, about 7,500 tons per year will be produced.

Lower world prices for tin during 1968 created need for Corporacion Minera de Bolivia (COMIBOL), Bolivia's national mining company, to seek cost savings through greater efficiency and in diversification from tin. Increased production of silver appeared to be one alternative. The company studied new technologies permitting more profitable use of Bolivia's predominately low-grade tin ores, and set out to initiate as many process improvements as possible. Other savings were under additional study, such as that performed for COMIBOL by the English firm of Head Wrightson Process Engineering, Ltd. This engineering feasibility and design study was expected to propose a plant to further beneficiate tin from existing Bolivian concentrators. Increased tin recovery would be achieved, under the proposal, by mechanical, chemical, and pyrometallurgical processes. High-grade tin concentrate, sulfuric acid, metallic silver, bismuth, and copper would thus be produced.

During the summer, a plant to recover tin from tailings at Bolivia's big Catavi mine went into operation. The plant has capacity to process 9,500 long tons of mine waste per day from which about 95 long tons of tin per month would be recovered.

Congo (Kinshasa).—Compagnie Geologique Minere des Ingenieurs et Industries Belges, Societe Anonyme (GEOMINES) was transformed, during 1967-68, into a new company under Congolese law. The new firm, Congo Etain, is owned 50-50 by GEOMINES and the State. GEOMINES has no mining function in the new entity but manages the technical, administrative, and marketing phases of Congo Etain. The company produced 2,400 long tons of cassiterite in the year ending June 30, 1968 and employed about 3,300 persons.

Indonesia.—Government efforts to reestablish Indonesia as a major world tin producer apparently met with some success. The opening of onshore and offshore areas to exploration and development, plus other attractive provisions, brought many companies and groups into the competition. In early July it was announced that Indonesia and N.V. Billiton Maatschappij of the Netherlands had signed a 40-year agreement for tin exploration and exploitation in offshore areas of Indonesia's Continental Shelf nearly as large as the Netherlands. One of the areas is near Sumatra between the islands of Singkep and Bangka and the other is off the southwest coast of Kalimantan. With this contract, Billiton returns to the country in which it began, bringing with it nearly a century of experience with tin extraction both in Indonesia and at sea.

Other companies negotiating for tin exploitation concessions, onshore and/or offshore in 1968, were the Rio Tinto Zinc Corp. of Great Britain, Bethlehem Steel Corp. of the United States, Simons-Lobnitz, Ltd., of Glasgow and a consortium, Ocean Science and Engineering (Swiss-based), Mary Kathleen Investments of Australia, and Amerada, Dillingham, and Signal Oil, all of the United States. Overseas Mineral Resources Development of Japan, Kennecott Copper Corp. of the United States, Placer Development (headquartered in Vancouver, British Columbia, Canada) also were actively negotiating.

Indonesia's first tin smelter, on the island of Bangka, experienced startup and shakedown problems during the year but solutions promised expanding output. Meanwhile, concentrates were going to Penang for smelting at the Straits Trading Works in Butterworth.

Malaysia.—At yearend 1968, there were 1,100 Malaysian tin mines in active production (1,072 at yearend 1967). Softening tin prices and gradual lowering of the values of ore being mined and dredged indicated a need in 1968 for strengthening the price picture and development of new tin reserves. Some sources called Malaysia's tin deposits "depleted," despite her world production leadership. To gain new reserves of tin, which creates about 25 percent of Malaysia's income, onshore Malaysian areas were opened to prospecting, and offshore prospecting, particularly in the Straits of Malacca, off Malaysia's western coasts, was particularly encouraged.

Under the export controls formulated by the ITC in September, Malaysia's exports were to equal those prevailing in 1967 and while there was likelihood that some marginal mines would close, the Malayan tin mining industry generally favored the move. The Malaysian Government formed a tin pool under which those mines unable to fill their production quotas surrendered their allowable balance to those mines which could produce in excess of their own quota allocations. In this way, it was argued, Malaysia would be able to export the maximum allowed under the restriction. Renewal of the scheme for first quarter 1969 also met with general approval.

Efforts by Malaysian state and central governments to achieve momentum in the exploration for and development of offshore tin reserves were protracted by legal and negotiation maneuvering during 1968. A total of 15 mining companies, three of which were foreign, had applied for the offshore prospecting rights. In April the Malaysian Government officially announced that three foreign companies had been granted 12-mile seaward prospecting rights: Ocean Mining Company (Swiss registered —owned by De Beers Corp. of London and Ocean Science and Engineering, Inc., of Washington, D.C.), off the States of Kedah and Perlis; Conzinc Riotinto Malaysia Ltd. (joint venture of local interests with Riotinto Finance & Exploration Ltd., London with a subsidiary of Bethlehem Steel Corp. of the U.S.), off the States of Penang, Perak, and Selangor; and the Billiton Company (Dutch), off the States of Negri Sembilan, Malacca, and Johore. Another site off the east coast opposite the State of Trengganau was also under consideration. By yearend the Malaysian Government was assembling a negotiating team to finalize the arrangements, but delays had developed because of a law permitting each state government to grant onshore prospecting licenses. This had created differences of opinion between the state and central governments on the general policy of joint ventures and how such schemes should proceed. At least one local company was, however, reportedly prospecting for tin off Malacca by mid-1968.

Several new onshore mines, operated either by individual companies or by the state mining entities, got into operation during the year.

Malaysia signed trade agreements during 1968 with Bulgaria and with the Soviet Union. Officials explained that such agreements would permit both countries to deal directly with Malaysia instead of through Singapore as in the past. Among the commodities to be sent to the Eastern Europe nations was tin. Manufactured goods would make the reverse journey. Trade agreements were also under negotiation between Malaysia and Yugoslavia, Rumania, and Hungary.

Illegal offshore mining in Malacca Straits west of the Malaya Peninsula from converted fishing vessels was of sufficient magnitude that rewards were offered by the Government for apprehension of the illegal operators. Apparently these operations increased after imposition in September of export controls. It was reported in December that the Sultan of Perak had led a police sortie on a number of the converted fishing vessels; damaged, seized, or sank seven out of the 27 observed; and destroyed their shore base. Each vessel was said to be capable of recovering around 700 pounds of cassiterite on a 24-hour operation.

Nigeria.—Cassiterite mining and the Markeri tin smelter, which treats the entire output of Nigerian tin concentrates are both somewhat removed from the scene of Nigeria's civil conflict. Accordingly, the nation has managed to maintain its tin output, but the obstacles have been numerous. Labor and staff shortages, transportation upheavals, increasing costs, higher taxes, price weaknesses and nondevaluation of the Nigerian pound all conspired to strain the industry's vigor. Some relief from Government royalty charges came in July 1968, when the royalty on tin metal was reduced $84.00 per ton of cassiterite, but mining companies appeared unanimous in their opinion that this cut was not deep enough to assure much expansion in production. The Federal Ministry of Mines and Power made loans available to small tin producers for the purchase of equipment in order to help step up their output. The export controls imposed by the International Tin Council did not have serious repercussions on Nigeria's tin output.

Thailand.—The Government of Thailand, in 1968, expressed eagerness to assist those interested in investment opportunities. Tin, the most important mineral produced in Thailand, is the second most important export commodity (after rice). Thus, tin mining and smelting seemed certain to benefit from the favorable development policy. Tin concentrate production showed a gentle upward climb during 1968 as several new mines and new types of equipment went into operation.

Smelting at the Phuket plant of the Thailand Smelting & Refining Co., Ltd. (THAISARCO) was keeping closer pace with actual mine production in 1968 than had been true in the previous year. The plant was geared to smelt all of Thailand's tin production for the foreseeable future. Some 92 percent of Thai tin is found in the south. Most deposits are alluvial with an occasional lode being worked; gravel pumping or dredging are the most common forms used for winning the ore. Offshore deposits also began to prove attractive although Thailand's unprotected waters and deep offshore tin deposits created problems for the tin dredges, some of which were still unsolved.

United Kingdom.—In addition to ongoing new mining operations in Cornwall, which had been in progress for several years by 1968, there were a number of ventures which were successfully recovering tin from old tailings dumps, and from tailings streams. In most of the tailings operations there were 2 to 4 pounds of tin to be extracted for each ton of tailings handled. Elsewhere, one marine dredge was running-in before beginning commercial operation.

Meanwhile, a research program at the University of Bristol, supported by a Science Research Council grant of $34,000, sought further improvement in the extraction of tin from its ores. Sale of devices developed would be worldwide as well as to the domestic mining industry. The same group had made a number of important contributions to the recovery of tin from tailings.

TECHNOLOGY

Discovery of new tin ore reserves in pockets in limestone bedrock which sometimes underlie known but nearly exhausted alluvial tin deposits in Malaysia has brought forth a new method of mining in the area. At old hydraulic mines, rather than move blasted and broken limestone bedrock via crawler-mounted equipment to a point where it can be crushed, Malaysian operators turned to pneumatic-tired front-end loaders. Working in water-borne shot rock proved very tough on crawling vehicle undercarriages. Rubbertired loaders helped to keep operating costs within manageable bounds and were more agile and could handle the broken rock or tin-bearing tailings material much faster. They also were used to move barren rock, build roadways, etc.[3]

Proceedings of, and all 26 papers presented at the First Technical Conference on Tin, sponsored by the International Tin Council and held in London in March 1967, were published.[4] The conference considered geological, mineralogical, technical, and administrative problems which might handicap tin production.

Promising possibilities exist for seekers of tin, beryllium, and tungsten in the Lake George Area of south-central Colorado, according to a report published in October 1968, by the U.S. Geological Survey. Basis for this report were studies of the geologic setting of the region plus geochemical samples which indicated further prospecting was warranted.[5]

---

[3] Engineering and Mining Journal. Tin Reserves of the Malay Penninsula May be Much Larger Than Expected, v. 169, No. 11, November 1968, p. 116.

[4] International Tin Council (London). A Technical Conference on Tin, 1967. 1968; v. 1, 349 pp.; v. 2, 299 pp.

[5] Hawley, C. C., and W. R. Griffitts. Distribution of Beryllium, Tin and Tungsten in the Lake George Area, Colorado. U.S. Geol. Survey Circ. 597, 1968, 18 pp.

The use of molten tin as a float bath for making large, exceptionally smooth plates of glass continued to meet with favor in the United States, and in 1968 the Libbey-Owens-Ford Glass Company (L-O-F) announced construction of its fourth float-glass facility, to cost $19 million, at a site already used by L-O-F at Ottawa, Ill. Much of this type of plate glass goes to the automobile industry, and a number of companies use the process. Float glass is made by pouring, or floating, molten glass across the top of a molten tin bath. The glass thus made is very flat and very smooth, requiring little additional polishing. Tin baths use large amounts of tin at the outset, but consumption of tin, once in operation, is limited to small process losses.

Tin-based chemicals are finding widening applications each year. A subsidiary of American Can Co. developed BIOMET-12, a tin-based organic chemical compound which, when sprayed upon pipes, cables, wood, paper, or plastics drives gnawing rodents away. The savings to the electric power and communications industries alone reportedly could be very sizable.[6] Tin use as a plating over aluminum was described,[7] and its use as an organotin-based paint for antifouling purposes on aluminum hulled boats was discussed.[8] Organotins combined with rubber provide antifouling protection for 5 years in tropical waters when applied to underwater surfaces of buoys, pilings, and ship hulls.[9]

---

[6] American Metal Market, Tin Base Liquid Chases Rodents. V. 75, No. 209, Oct. 29, 1968, pp. 1–2.

[7] American Metal Market, New Process for Plating Tin on Aluminum Developed. V. 75, No. 95, May 16, 1968, p. 24.

[8] The Tin Research Institute (Middlesex, England). Organotin Paint for Boats. Ch. in Tin and Its Uses, Bull. 78, 1968, p. 4.

[9] Bulletin of the Malayan Tin Bureau (Washington, D.C.). March 1968, pp. 6.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/12

Titanium

By John G. Parker[1]

World production of titanium concentrates increased in 1968. U.S. production of ilmenite concentrate increased 5 percent but U.S. imports of Australian ilmenite sagged considerably. Rutile from Australia and titanium slag from Canada increased but rutile imports from Sierra Leone were much lower than in the previous year. Imports of titanium sponge and waste and scrap were more than 50 percent lower but those of the oxide were 14 percent higher than in 1967.

A slowdown in aerospace programs, a strike at a reduction plant, and large inventories led to lower metal sponge production and consumption.

Titanium pigment production and consumption increased significantly; a new producing plant went on stream, and expansion of current operations was announced.

Legislation and Government Programs.—There were no sales of titanium sponge metal by General Services Administration (GSA) from the Defense Production Act (DPA) inventories. The stockpile objectives for rutile and titanium sponge metal remained at 200,000 tons and 37,500 tons, respectively. The Government inventory of rutile at the end of 1968 was 50,297 tons, having risen over 3,000 tons from the previous year due to delivery of Australian rutile.

Government exploration assistance for rutile, available through the Office of Minerals Exploration, U.S. Geological Survey, remained at 75 percent of the approved costs of exploration.

The Department of the Interior, acting under authorization by the Office of Emergency Preparedness (OEP), continued its investigation of potential sources of domestic rutile as well as encouraging and expediting production and use of substitute domestic and other North American titaniferous ores. The role of the Bureau of Mines in this program was to examine the technology and economic factors involved in producing and using alternate titaniferous materials instead of rutile in strategic applications.

Acting on advice that Soviet titanium sponge was being, or was likely to be, sold in the United States at less than fair value, on April 24 the U.S. Tariff Commission, under section 201(a) of the Antidumping Act, 1921, as amended, began investigating the possible injury to the U.S. industry of such importations. On June 4 and 5, public hearings were held, and on July 23, the Commission gave an affirmative ruling on the dumping charge.

---

[1] **Physical scientist, Division of Mineral Studies.**

Table 1.—Salient titanium statistics

	1964	1965	1966	1967	1968
United States:					
Ilmenite concentrate:					
Mine shipments........short tons..	1,003,997	948,832	868,436	882,414	960,118
Value................thousands..	$19,178	$18,058	$17,608	$18,519	$19,484
Imports..............short tons..	173,219	166,315	186,539	207,906	246,109
Consumption...............do....	980,426	923,304	962,706	919,206	959,558
Titanium slag: Consumption.....do....	128,203	148,184	132,233	122,926	142,168
Rutile concentrate:					
Mine shipments............do....	10,547	W	W	W	W
Value................thousands..	$1,016	W	W	W	W
Imports..............short tons..	110,981	151,748	151,482	167,100	174,366
Consumption...............do....	79,446	117,376	135,883	153,457	160,278
Sponge metal:					
Imports for consumption.....do....	2,039	3,134	5,225	7,144	3,448
Consumption...............do....	11,131	12,105	19,677	20,062	14,237
Price: December 31 per pound......	$1.32	$1.32	$1.32	$1.32	$1.32
World: Production:					
Ilmenite concentrate........short tons..	2,589,898	2,705,425	2,886,937	3,018,743	3,216,063
Rutile concentrate...............do....	214,755	245,259	275,198	337,067	356,682

W Withheld to avoid disclosing individual company confidential data.

DOMESTIC PRODUCTION

Concentrates.—Output of ilmenite concentrate rose 5 percent in 1968. Producers of the concentrate were E. I. du Pont de Nemours & Co., Inc., Starke and Highland, Fla.; Humphreys Mining Co., Folkston, Ga.; SCM Corporation, Glidden-Durkee Division, Lakehurst, N.J.; National Lead Co., Tahawus, N.Y.; American Cyanamid Co., Piney River, Va.; and M&T Chemicals, Inc., Hanover County, Va.

Rutile was produced solely by M&T Chemicals at its mine in Hanover County, but output was less than half of what it was in 1967.

Metal.—Production of titanium sponge by three companies was 25 percent lower than in 1967 because of a strike in the last quarter at the reduction plant of Reactive Metals, Inc., and to decreased demand. The sponge producing firms were Titanium Metals Corporation of America (TMCA), Henderson, Nev., owned by National Lead Co., and Allegheny Ludlum Steel Corp.; Reactive Metals, Inc., Ashtabula, Ohio, owned by National Distillers & Chemical Corp. and United States Steel Corp.; and Oregon Metallurgical Corp., Albany, Oreg., partly owned by Armco Steel Corp. and Ladish Co. The capacity of all three firms was about 20,000 tons of sponge per year.

Titanium ingot, production of which dropped 26 percent, was made from sponge metal and alloys by Crucible Steel Company of America, Midland, Pa.; Harvey Aluminum, Inc., Torrance, Calif.; Oregon Metallurgical Corp.; Reactive Metals, Inc., Niles, Ohio; TMCA; and Teledyne Titanium, Inc., a subsidiary of Teledyne, Inc., with a new plant in Monroe, N.C.

Oregon Metallurgical Corp. raised its ingot melting capacity to 6,500 tons annually with facilities which included a new melting furnace able to produce 5-ton, 30-inch-diameter ingots. Eventually, by the second half of 1969, the furnace will be able to accommodate 10-ton, 36-inch-diameter ingots. Titanium Technology Corp. (TiTech), a joint undertaking of Carpenter Steel Co. and Electronic Specialty Co., announced the start of construction of a new, 250-ton-per-year titanium and titanium alloy casting foundry at Pomona, Calif., scheduled to begin operating in spring 1969. Subsequently, Carpenter Steel indicated it would adapt some of its steel melting vacuum furnaces at Reading, Pa., to handle titanium. In August, TiLine, Inc., Albany, Oreg., began casting solid titanium and titanium linings for castings of other metals.

Pigment.—The gross weight of titanium dioxide (TiO_2) pigment produced domestically was 6 percent greater than that of 1967, with the average TiO_2 content of the rutile-, anatase-, and composite-type pigments being slightly higher than in the previous year. Rutile-type pigment, produced by all eight pigment companies, again was about 50 percent of the total on a TiO_2 content basis. Most of the remainder was anatase-type pigment, produced by 6 companies, and composite-type, produced by one company.

The following companies produced titanium pigments; American Cyanamid Co., Piney River, Va., and Savannah, Ga.; American Potash & Chemical Corp., a subsidiary of Kerr McGee Corp., Hamilton, Miss.; Cabot Titania, Inc., a wholly-owned subsidiary of Cabot Corp., Ashtabula, Ohio; E. I. du Pont de Nemours & Co., Inc., Edge Moor, Del., Baltimore, Md., Antioch, Calif., and New Johnsonville, Tenn.; National Lead Co., St. Louis, Mo., and Sayreville, N.J.; The New Jersey Zinc Co., a part of Gulf & Western Industries, Gloucester, N.J.; PPG Industries, Inc., with a new chloride processing unit, Natrium, W. Va.; and SCM, Glidden-Durkee Division, Baltimore, Md.

American Cyanamid's chloride process TiO_2 facility at Savannah, Ga., placed on standby in the fall of 1967, was to be expanded and modified, using patented techniques licensed from American Potash. Startup was expected in 1970. Also using the same patented techniques, SCM, Glidden-Durkee Division, decided to expand its operation at Baltimore 50 percent by building a highly automated, $20 million chloride-process plant.

Welding Rod Coating.—A total of 272,000 tons of welding rods, containing titaniferous materials in their coatings, was produced. Of the total output 46 percent contained rutile; 15 percent, ilmenite; 27 percent, a mixture of rutile and manufactured titanium dioxide; 8 percent, manufactured titanium dioxide; and 4 percent, miscellaneous mixtures and titanium slag.

Table 2.—Production and mine shipments of titanium concentrates from domestic ores in the United States

	Production short tons (gross weight)	Shipments		
		Short tons (gross weight)	Short tons TiO_2 content	Value (thousands)
Ilmenite:[1]				
1964	1,001,132	1,003,997	526,642	$19,178
1965	969,459	948,832	494,353	18,058
1966	965,378	868,436	451,132	17,608
1967	935,091	882,414	463,286	18,519
1968	978,509	960,118	506,260	19,484
Rutile:				
1964	8,062	10,547	10,112	1,016
1965–68	W	W	W	W

W Withheld to avoid disclosing individual company confidential data.
[1] Includes a mixed product containing rutile, leucoxene, and altered ilmenite.

Table 3.—Titanium–metal data

(Short tons)

	1964	1965	1966	1967	1968
Sponge metal:					
Imports for consumption	[r] 2,039	3,134	[r] 5,225	[r] 7,144	3,443
Industry stocks	800	900	800	2,900	2,600
Government stocks (DPA inventories)	22,254	22,339	21,416	20,711	20,711
Consumption	11,131	12,105	19,677	20,062	14,237
Scrap-metal consumption	2,877	3,303	4,857	5,822	4,701
Ingot:[1]					
Production	13,964	15,294	24,253	25,960	19,234
Consumption	13,501	14,694	22,317	25,386	18,323
Mill shape production [2]	7,708	9,358	13,996	[r] 13,634	11,900

[r] Revised.
[1] Includes alloy constituents.
[2] Bureau of the Census and Business and Defense Services Administration, Current Industrial Reports Series BDSAF–263. Net shipments derived by subtracting the sum of producers' receipts of each mill shape from the industry's gross shipments of that shape. Data not comparable for years before 1962.

Table 4.—Titanium pigment data
(TiO_2 content)

Year	Production (short tons)	Shipments [1]	
		Quantity (short tons)	Value, f.o.b. (thousands)
1964	558,536	549,829	$288,031
1965	576,700	578,091	[r] 298,368
1966	594,486	593,933	303,902
1967	[r] 589,449	582,325	297,283
1968	[p] 626,807	NA	NA

[p] Preliminary. [r] Revised. NA Not available.
[1] Includes interplant transfers.

Source: Bureau of the Census.

CONSUMPTION AND USES

Concentrates.—Consumption of rutile in 1968 increased 4 percent over that of 1967 and that of ilmenite and titanium slag rose 4 and 16 percent, respectively.

Metal.—Shipments of titanium mill products, a gage of metal demand, were 13 percent less than in 1967, and consumption of sponge metal was 29 percent less than in the previous year. Also, scrap metal consumption was lower than in any year since 1965. All this reflected a decrease in use of the materials in governmental and commercial aerospace programs, mainly in the delay of the C5A cargo plane and plans for the SST (supersonic transport).

A large domestic producer of titanium metal estimated the end-use distribution of titanium mill products as follows:

	Consumption, percent		
	1966	1967	1968
Jet engines	47	54	54
Airframes	28	35	33
Space and missiles	15	6	8
Nonaerospace	10	5	5
Total	100	100	100

Other countries, including the United Kingdom and the U.S.S.R., had an interest in titanium usage in aerospace applications. Over 6,000 pounds of titanium mill products were said to be used in a British aircraft motor, the Rolls Royce RB 211 engine, and titanium was said to be used in the powerplant and structure of a Soviet supersonic transport.

Also, because of its corrosion resistance, titanium received increased application in chemical processing equipment. For example, 5 years' usage as a replacement for cast iron in ammonia-recovery still tubes at an Ohio soda-ash plant has shown that their trouble-free long life is more than enough to pay for the cost differential over cast iron tubes.[2] At an electrolytic chlorine plant in Niagara Falls, N.Y., titanium tubes have been used in an acid-brine cooler since 1965 in place of impregnated graphite tubes, and in a urea manufacturing plant in Niagara Falls, Ontario, Canada, titanium was used to line reactors. Seamless titanium tubing in heat exchangers and evaporators in a St. Croix, Virgin Islands, desalination plant were expected to last 30 years without replacement.[3]

A titanium alloy with 6 percent aluminum and 4 percent vanadium, said to be the same alloy which will be used in the SST, was used in lightweight steam-turbine blades which resisted corrosion and boosted the turbine's horsepower output by 30 percent. The U.S. Army announced it was testing titanium alloy helmets in Vietnam which weighed ¾ to 1½ pounds less than the conventional manganese steel alloy helmet.

Compounds.—Titanium diboride is extremely resistant to corrosive attack by molten aluminum when used in pumps employed in hot-chamber die casting. Tough titanium carbide cutting inserts, with high edge wear and crater resistance, increase the life of tools used to semifinish, finish, and precision machine steel and alloy steels.

---

[2] McCallion, John. Titanium Sheds "Exotic" label. Chemical Processing, v. 32, No. 3, March 1968, pp. 19–21.

[3] Light Metal Age. Titanium in Seawater Conversion. V. 26, Nos. 5–6, June 1968, pp. 24–25.

Pigments.—Consumption of titanium pigment in 1968 on a gross weight basis and using shipments as a gage was 7 percent more than that in 1967.

Table 5.—Consumption of titanium concentrates in the United States, by products

(Short tons)

Year and product	Ilmenite [1]		Titanium slag		Rutile	
	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content	Gross weight	Estimated TiO_2 content
1964	980,426	511,053	128,203	91,868	79,446	76,328
1965	923,304	483,002	148,184	105,483	117,376	113,017
1966	962,706	507,379	132,233	93,683	135,883	130,191
1967:						
Pigments	916,398	486,739	122,926	86,945	96,401	92,795
Titanium metal	---------	---------	---------	---------	(2)	(2)
Welding-rod coatings	(2)	(2)	(3)	(3)	21,190	20,139
Alloys and carbide	2,414	1,265	(3)	(3)	737	697
Ceramics	(2)	(2)	---------	---------	(4)	(4)
Glass fibers	---------	---------	---------	---------	(2)	(2)
Miscellaneous	394	232	---------	---------	35,129	33,527
Total	919,206	488,236	122,926	86,945	153,457	147,158
1968:						
Pigments	957,114	509,013	142,168	100,591	112,856	108,544
Titanium metal	---------	---------	---------	---------	(2)	(2)
Welding-rod coatings	(2)	(2)	---------	---------	21,414	20,409
Alloys and carbide	2,097	1,133	(3)	(3)	728	659
Ceramics	(2)	(2)	---------	---------	(4)	(4)
Glass fibers	---------	---------	---------	---------	(2)	(2)
Miscellaneous	347	207	---------	---------	25,275	23,988
Total	959,558	510,353	142,168	100,591	160,273	153,600

[1] Includes a mixed product containing rutile, leucoxene and altered ilmenite.
[2] Included with "Miscellaneous" to avoid disclosing individual company confidential data.
[3] Included with "Pigments" to avoid disclosing individual company confidential data.
[4] Included with "Alloys and carbide" to avoid disclosing individual company confidential data.

Table 6.—Distribution of titanium-pigment shipments, by industries

(Percent)

Industry	1964	1965	1966	1967	1968
Distribution by gross weight:					
Paints, varnishes, and lacquers	62.6	62.9	61.6	61.9	60.7
Paper	12.4	12.6	13.9	14.6	14.9
Floor coverings	3.9	3.6	3.4	2.7	2.4
Rubber	3.1	4.2	4.2	2.8	2.9
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.2	1.4	1.4	1.4	1.4
Printing ink	1.7	1.8	1.9	2.0	2.1
Roofing granules	1.6	1.3	1.2	1.1	.8
Ceramics	1.5	1.5	1.7	1.9	2.1
Plastics (except floor covering and vinyl-coated fabrics and textiles)	4.4	3.6	3.8	5.1	6.0
Other (including export)	7.6	7.1	6.9	6.5	6.7
Total	100.0	100.0	100.0	100.0	100.0
Distribution by titanium dioxide content:					
Paints, varnishes, and lacquers	56.8	57.4	56.4	57.5	56.5
Paper	15.2	15.2	16.7	17.2	17.4
Floor coverings	4.7	4.3	3.9	3.1	2.7
Rubber	3.7	5.0	4.9	3.2	3.3
Coated fabrics and textiles (oil cloth, shade cloth, artificial leather, etc.)	1.4	1.6	1.6	1.6	1.6
Printing ink	2.1	2.1	2.2	2.3	2.4
Roofing granules	1.9	1.7	1.5	1.4	1.0
Ceramics	1.9	1.8	2.1	2.2	2.4
Plastics (except floor covering and vinyl-coated fabrics and textiles)	5.4	4.3	4.6	6.0	6.9
Other (including export)	6.9	6.6	6.1	5.5	5.8
Total	100.0	100.0	100.0	100.0	100.0

STOCKS

Industry stocks of rutile increased 17 percent to 218,500 tons, equivalent to about one and a third year's supply at the 1968 consumption rate. Ilmenite inventories rose 5 percent but stocks of titanium slag decreased 8 percent. Yearend stocks of sponge metal owned by producers, melters, and semifabricators were 2,620 tons, 8 percent less than in the previous year. Metal scrap held by melters and semifabricators was 4,434 tons compared with 4,894 tons at the end of 1967. Stocks of composite and pure TiO_2 held by producers were 9 percent less than the previous year—94,252 tons compared with 103,290 tons.

Table 7.—Stocks of titanium concentrates in the United States, Dec. 31

(Short tons)

Year and stock	Ilmenite		Titanium slag		Rutile	
	Gross weight	TiO_2 content estimated	Gross weight	TiO_2 content estimated	Gross weight	TiO_2 content estimated
1967:						
Mine	(1)	(1)	---------	---------	(1)	(1)
Distributor	[r] 195,040	[r] 119,240	(2)	(2)	[r] 12,145	[r] 11,635
Consumer	660,712	[r] 363,761	130,389	92,310	[r] 174,135	[r] 167,326
Total	[r] 855,752	[r] 483,001	130,389	92,310	[r] 186,280	[r] 178,961
1968:						
Mine	(1)	(1)	---------	---------	(1)	(1)
Distributor	213,410	133,074	---------	---------	17,142	16,454
Consumer	682,000	373,350	119,746	84,743	201,375	193,388
Total	895,410	506,424	119,746	84,743	218,517	209,842

[r] Revised.
[1] Included with "Distributor" to avoid disclosing individual company confidential data.
[2] Included with "Consumer" to avoid disclosing individual company confidential data.

PRICES

Concentrates.—At yearend, imported ilmenite (54 percent TiO_2), f.o.b. Atlantic ports, was quoted in Metals Week at $20 to $21 per long ton of contained TiO_2, $1 to $3 per ton less than at yearend 1967. Contrarily, rutile (96 percent TiO_2) rose $2 to $4 to $121 to $125 per short ton of contained TiO_2, f.o.b. cars Atlantic ports. According to Metals Week bulk sales often were made at $100 per ton but some sales were as high as $130 per long ton.[4] The quoted price for domestic ilmenite, (60 percent TiO_2) f.o.b. Florida, ranged from $30 to $35 per short ton, but Canadian titanium slag (70 percent TiO_2) remained at $43 per long ton.

Manufactured Titanium Dioxide.—The base prices of anatase grades of manufactured titanium dioxide pigment and calcium-rutile base titanium pigments were unchanged from 1967. Anatase titanium dioxide of paper grade, however, was 3.5 cents per pound less than other anatase grade oxides. Rutile grade oxide pigment increased 1 cent per pound. At yearend the following prices were quoted in Oil, Paint and Drug Reporter.

	Price per pound
Anatase, chalk-resistant, regular and ceramic:	
Carlots, delivered	$0.255
Less than carlots, delivered	.265
Rutile, nonchalking, bags:	
Carlots, 20 tons, delivered, East	.285
Less than carlots, delivered East	.295
Titanium pigment, calcium-rutile base:	
30 percent TiO_2, bags:	
Carlots, 20 tons, delivered	.09375
Less than carlots, delivered	.09875
50 percent TiO_2, bags:	
Carlots, 20 tons, delivered	.14375
Less than carlots, delivered	.14875

---

[4] Metals Week. Upgraded ilmenite: Will it be tomorrow's source of titanium metal? V. 39, No. 53, Dec. 30, 1968, pp. 12–14.

Metal.—Prices for various grades of titanium sponge of domestic, British, and Japanese origin (99.3 percent maximum titanium; Brinell hardness number 115 maximum) were quoted in Metals Week at yearend as follows:

	Price per pound
Domestic titanium sponge	$1.32
Japanese and British titanium sponge	$1.20–$1.25

Until the middle of August, when quotations were discontinued on Soviet titanium sponge, Metals Week quoted prices on this material ranging from $0.97 to $1.10 per pound for 99.6 percent pure metal in 100- to 500-pound lots.

Ferrotitanium.—Nominal prices (unchanged from 1967) at the end of 1968 for various grades of this alloy were quoted in Metals Week as follows:

	Price
Low-carbon, 25–40 percent titanium, per pound	$1.35
Medium-carbon, 17–21 percent Titanium, per short net ton	375.00
High-carbon, 15–19 percent titanium, per short net ton	310.00

FOREIGN TRADE

Titanium dioxide exports to 58 countries, mostly to Canada (50 percent) and to South Korea and the Philippines (about 10 percent each), increased 17 percent to 30,188 tons valued at $8,226,779. The quantity of ores and concentrates exported to six countries increased 40 percent; the unit value increased almost $10 per ton. Canada received 75 percent by weight of the ore exports, but the unit values of the shipments to Canada were much lower than exports to any of the other nations. Although exports of unwrought metal and alloy, waste and scrap to 13 countries (80 percent to Canada) increased over 90 percent, there was a 47-percent decrease in unit value. On the other hand, there was a 32-percent decrease in exports of combined intermediate titanium mill shapes and wrought metal and alloys as well as a 16-percent decrease in unit value. Canada again received most (83 percent) of the shipments of intermediate mill shapes to 20 foreign countries, but only 49 percent of shipments of wrought titanium and alloys sent to 31 countries.

Imports of ilmenite from Australia decreased considerably, but those of titaniferous concentrates, mostly slag, from Canada increased 36 percent while their unit value decreased by 24 percent. Although rutile imports from Australia continued to increase, those from Sierra Leone, owing to an interruption in that country's output, dropped off to only about 10 percent of what they were in 1967. Imports for consumption of 3,443 tons of unwrought titanium and waste and scrap from six countries were less than one-half of what they were in the previous year. Japan shipped the United States over 70 percent (2,466 tons) of these materials, practically all as titanium sponge. The United Kingdom and the U.S.S.R. also supplied the United States with significant quantities of sponge metal. Most of the remaining items under this import category, largely scrap, came from Canada. The steadily climbing imports of wrought metal, from six countries in 1968 and 62 percent from Japan, were about 20 percent greater than the 1967 total. Imports of titanium dioxide from 12 countries, principally from Japan, West Germany, France, Finland, Spain, and the United Kingdom, totaled 53,324 tons valued at $18,667,976.

The tariff on titanium sponge, waste, and scrap was lowered to 19.5 percent ad valorem on January 1, 1968, but the suspension of duty on waste and scrap was continued through the year.

Table 8.—U.S. exports of titanium products, by classes

Year	Ores and concentrates		Metal and alloy sponge and scrap		Intermediate mill shapes and mill products, n.e.c.[1]		Dioxide and pigments	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	1,300	$213	1,733	$1,988	1,371	$9,585	26,872	$7,501
1967	3,027	167	1,429	1,703	r 1,812	r 13,366	25,852	7,165
1968	4,238	276	2,756	1,748	1,228	7,575	30,188	8,227

r Revised.
[1] Not elsewhere classified.

Table 9.—U.S. imports for consumption of titanium concentrates, by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Ilmenite:						
Australia	46,245	$366	60,689	$524	45,196	$380
Canada	140,237	6,329	147,216	4,621	200,913	4,787
Other countries	57	3	1	(2)	---------	---------
Total	186,539	6,698	207,906	5,145	246,109	5,167
Rutile:						
Australia	151,463	8,493	153,768	11,029	171,847	12,508
Sierra Leone	19	1	13,129	898	1,348	91
Other countries	(1)	(2)	203	16	1,171	54
Total	151,482	8,494	167,100	11,943	174,366	12,653

[1] Chiefly titanium slag averaging about 70 percent TiO_2.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—New estimates of Australian titanium mineral reserves were reported and are as follows, in thousand long tons:[1]

Company	Ilmenite	Rutile
Associated Minerals Consolidated Ltd	------	1,900
Cable (1956) Ltd	2,250	-----
Coastal Mining Development Pty. Ltd	------	50
Consolidated Rutile Ltd	------	600
Cudgen R.Z. Ltd	------	560
Mineral Deposits Pty. Ltd	------	1,230
Murphyores Holdings Ltd	[2] 5	[2] 837
Naracoopa Rutile Ltd	------	100
Northern Rivers Rutile Pty. Ltd	------	50
Queensland Titanium Mines Pty. Ltd	------	600
Rutile and Zircon Mines (Newcastle) Ltd	------	750
Signal-Dillingham	------	100
Titanium and Zirconium Industries Pty. Ltd	------	100
Western Mineral Sands Pty. Ltd [3]	3,000	-----
Western Titanium N.L.[3]	8,500	-----
Westralian Sands Ltd.[3]	2,250	-----
Total [4]	16,000	6,900

[1] Financial Review (Sydney), Feb. 15, 1968.
[2] Industrial Minerals (London). No. 8, May 1968, p. 22.
[3] West Coast operation.
[4] Rounded.

One-third of the stocks of N.S.W. Rutile Mining Co. Pty., Ltd., the last of the privately owned mineral sands producers on the east coast, were offered to the public by Murphyores Holdings Ltd.[5] Murphyores new dry processing operation at Barney Point, Gladstone, Queensland, to be ready early in 1969, was scheduled to have an initial output of 93,000 tons per year of ilmenite, rutile, and zircon concentrates. Material processed will be obtained from a 300-ton-per-day floating dredge on Rodd's Peninsula.

Australian ilmenite producers sought to develop salable grades of beneficiated ilmenite (synthetic rutile) to fill the gap left by a shortfall of rutile. Murphyores planned to produce commercial tonnages of upgraded ilmenite of rutile grade at Gladstone by 1971, and at Capel, Western Australia, Western Titanium N.L. commissioned a semicommercial upgrading

---

[5] Industrial Minerals (London). No. 6, March 1968, p. 22.

Table 10.—World production of titanium concentrates (ilmenite and rutile) by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
Ilmenite:					
Australia (shipments) [2]	[r] 340,799	[r] 494,385	[r] 575,420	604,438	616,181
Brazil [3]	9,117	10,796	14,920	16,498	19,710
Canada (titanium slag) [4]	544,721	545,916	524,773	602,455	672,866
Ceylon	50,880	54,222	[5] 45,415	58,573	[5] 82,242
Finland	127,937	117,947	129,588	139,883	154,000
India	13,273	33,132	33,253	45,840	64,733
Japan (titanium slag)	2,161	3,190	3,867	6,293	4,624
Malagasy Republic	5,291	6,957	6,821	2,047	----------
Malaysia [5]	144,774	136,154	130,364	100,097	138,698
Norway	299,854	311,017	[r] 407,553	464,089	• 441,000
Portugal	63	83	[r] 530	590	• 550
Senegal	1,455	----------	----------	----------	NA
Spain	48,418	[r] 22,167	46,548	41,728	• 43,000
United Arab Republic	23	----------	[r] 2,507	1,171	NA
United States [6]	1,001,132	969,459	965,378	935,091	978,509
Total ilmenite	[r] 2,589,898	[r] 2,705,425	[r] 2,886,987	[r] 3,018,743	3,216,063
Rutile:					
Australia	204,256	243,410	[r] 273,122	306,236	323,665
Brazil [3]	315	397	37	313	[3] 126
Ceylon	----------	----------	----------	----------	1,270
India	2,062	1,452	2,002	2,798	2,961
Senegal	60	----------	----------	----------	NA
Sierra Leone	----------	----------	----------	27,713	28,660
United Arab Republic	----------	----------	37	7	NA
United States	8,062	W	W	W	W
Total rutile [7]	214,755	245,259	[r] 275,198	[r] 337,067	356,682

• Estimate. [p] Preliminary. [r] Revised. W Withheld to avoid disclosing individual company confidential data. NA Not available.

[1] Titanium concentrates are produced in U.S.S.R., but no reliable figures are available.
[2] Includes small quantities of leucoxene concentrates.
[3] Production—Comissao Nacional de Energia Nuclear only.
[4] Containing approximately 70–72 percent TiO_2.
[5] Exports.
[6] Includes a mixed product containing ilmenite, leucoxene, and rutile.
[7] Total is of listed figures only.

plant.[6] The Capel plant was designed to upgrade ilmenite from 55–56 percent to 93 percent TiO_2.[7]

Signal Oil and Gas Co. Los Angeles, and Dillingham Corp., Honolulu, bought mineral sand leases on 30,000 acres of land and dry processing plants at Kincumber and Woodburn N.S.W. from Northern Rivers Rutile Pty. Ltd.[8]

Belgium.—A new 20,000-ton-per-year titanium dioxide pigment production facility, using the sulfate process, was to be built before the end of 1970 by N.V. Bayer S.A., a subsidiary of Farbenfabriken Bayer, A.G., Antwerp.[9]

Canada.—A new chloride unit with a production capacity of 10,000 tons of TiO_2 due for completion in the spring of 1969, was under construction at the Varennes, Quebec plant of Canadian Titanium Pigments, Ltd., a subsidiary of National Lead Co. Sté. Quebecoise d'Exploration Miniere (SOQUEM), a Quebec Government-owned company, investigated the titaniferous magnetite deposit at Magpie, north of Minegan.[10]

Ceylon.—A 3-year contract, under which Japanese titanium dioxide makers will receive up to 70,000 tons of ilmenite per year, was expected to lead to expansion of the Pulmoddai plant owned by the Government-controlled Ceylon Mineral Sands Corp. to 72,000 tons per year output.[11]

---

[6] Australian Mineral Industry. Quarterly Review. Quarterly Statistics. V. 21, No. 1, September 1968, p. 12.

[7] Industrial Minerals (London). No. 7, April 1968, p. 21.

[8] Industrial Minerals (London). No. 4, January 1968, p. 24.

[9] Industrial Minerals (London). No. 15, December 1968, p. 23.

[10] Industrial Minerals (London). No. 16, January 1969, p. 41.

[11] Industrial Minerals (London). No. 10, July 1968, p. 26.

Table 11.—Australia: Exports of ilmenite concentrates, by countries

(Short tons)

Destination	1964	1965	1966	1967	1968 p
France	45,406	28,947	53,215	90,674	134,635
Japan	55,876	50,884	49,362	69,272	75,501
Netherlands	411	333	7,417	(1)	(1)
South Africa, Republic of	20,017	24,640	11,314	(1)	(1)
Spain	(1)	(1)	7,078	67	11,421
United Kingdom	136,516	225,912	216,668	186,704	173,144
United States	17,130	72,913	53,928	54,451	33,599
Other countries	227	376	260	29,248	15,120
Total	275,583	404,005	399,237	430,416	443,420

p Preliminary. [1] Included with "Other countries."

Table 12.—Australia: Exports of rutile concentrates, by countries

(Short tons)

Destination	1964	1965	1966	1967	1968 p
Belgium	4,287	4,084	2,465	(1)	(1)
Canada	(1)	(1)	5,499	5,419	26,649
France	9,803	12,758	13,642	8,732	9,668
Germany, West	10,625	9,051	10,750	11,443	7,865
Italy	6,851	5,915	6,287	(1)	(1)
Japan	17,832	22,715	24,431	32,913	34,287
Netherlands	15,206	12,601	9,859	21,034	18,325
Sweden	4,454	4,742	3,857	(1)	(1)
United Kingdom	17,187	18,923	17,343	17,862	18,572
United States	107,539	152,479	136,556	146,021	164,528
Other countries	23,376	24,920	28,355	46,422	39,300
Total	217,160	268,188	259,044	289,846	319,194

p Preliminary.
[1] Included with "Other countries."

Germany, West.—Effluent disposal apparently was solved for the time being when the three titanium dioxide pigment producers—Farbenfabriken Bayer, Pigment Chemie G.m.b.H., and Titangesellschaft A.G.—entered a 13-year agreement to barge dilute waste acid to Rotterdam. There it would be transferred to ocean-going tankers and dumped into specified areas in the North Sea.[12] Meanwhile, Titangesellschaft, a National Lead Co. subsidiary, was constructing a new, sulfate process plant with an initial annual capacity of 36,000 tons of TiO_2 at Blexner Groden, near Nordenham, with completion scheduled for the spring of 1969. Farbenfabriken Bayer A.G. was installing a chloride processing unit with a capacity of 21,000 tons of TiO_2 per year at Uerdingen, Westfalen, thus bringing its total company capacity up to 75,000 tons of TiO_2 per year.

India.—Travancore Titanium Products Ltd. (TTP) signed an agreement with the Power Gas Corp. Ltd. (UK) to raise the annual capacity of its dioxide plant at Trivandrum, Kerala State, from 6,000 to 24,000 tons by 1970.[13]

An ambitious $53 million program to construct a large integrated titanium complex in Kerala State was unveiled.[14] On a 900-acre site near Cochin, Bhallarpur Paper and Straw Board Mills, with foreign collaboration, hoped to revive the Indian beach sand industry by building facilities to produce high-grade titanium slag, oxide, tetrachloride, and sponge metal.

Japan.—The combined production of titanium sponge by the two producers, Osaka Titanium Co. Ltd., Amagasaki,

---

[12] Industrial Minerals (London). No. 4, January, 1968, p. 26.

[13] Chemical Age (London). V. 98, No. 2547, May 11, 1968, p. 25.

[14] Metals Week. V. 39, No. 32, Aug. 5, 1968, p. 19.

Hyogo Prefecture, and Toho Titanium Co., Ltd., Chigasaki, Kanagawa Prefecture, was 5,983 short tons, whereas the only output of titanium slag (4,624 tons) emanated from Hokuetsu Metal Co.[15] During the year the firms were said to have cut output 50 percent owing to low U.S. demand.[16]

All seven titanium dioxide pigment producers still use the sulfate instead of the chloride process. Ishihara Sangyo Kaisha Ltd., Osaka, a large titanium oxide producer, raised the plant capacity at Yokkaichi by 50 percent to 6,600 short tons per month.[17]

Table 13.—Malaysia: Exports of ilmenite by countries

(Short tons)

Destination	1963	1964	1965	1966	1967
Belgium	19,470	14,663	22,184	(1)	(1)
France	63,194	58,805	27,351	(1)	(1)
Japan	81,537	71,037	86,300	106,832	100,039
Other countries	455	269	319	23,532	58
Total	164,656	144,774	136,154	130,364	100,097

[1] Included with "Other countries."

Another of the larger firms, the Sakai Chemical Industry Co. Ltd., Osaka Prefecture, was adding 500 tons per month to the existing capacity of 1,750 tons per month at its Onahama plant.

Mexico.—Pigmentos y Productos Quimicos, S.A. de C.V., Tampico, a 49-percent-owned affiliate of E. I. du Pont de Nemours & Co., Inc., increased its sulfate process TiO_2 capacity from 10,000 to 14,000 tons per year with an additional 4,000 tons more planned for late 1969.

Netherlands.—In the Rotterdam area, N.V. Titaandioxydefabriek Tiofine (TDF), owned 50 percent by American Cyanamid Company, completed modernizing and expanding its sulfate process titanium dioxide plant.[18]

New Zealand.—Ilmenite-bearing sands in the Westport area, South Island, were investigated as a source of pigment feed by Rutile and Zircon Mines (Newcastle) Ltd., Sydney, Australia, in conjunction with Buller Minerals Ltd., Nelson, New Zealand, and the chemistry division of the New Zealand Department of Scientific and Industrial Research.[19] If large-scale production is proved commercially feasible, a titanium slag plant of 200,000 tons annual capacity was foreseen. Total ilmenite reserves near Westport were estimated at between 17 and 31 million tons.

Sierra Leone.—In June, about 6 months after its large hydraulic dredge sank, Sherbro Minerals Ltd., a subsidiary of PPG Industries, Inc., and British Titan Products Co. Ltd., refloated and repaired the dredge and resumed production of alluvial rutile near the Sherbro estuary on the southwest coast, about 60 miles from Freetown.

United Kingdom.—A new titanium melting furnace installed at Imperial Metal Industries' Kynoch works at Witton, a Birmingham suburb, has an annual capacity of 900 ingot tons, raising the total capacity at Witton to 3,500 ingot tons.[20] A greater efficiency is claimed because the crucibles are cooled with a liquid metal alloy of sodium and potassium, which will not react explosively with liquid titanium as will water.

A new 30,000-ton-per-year chloride processing unit, to be built by British Titan Products Co. Ltd. at Greatham, will raise the total capacity to about 250,000 tons per year of titanium dioxide.[21] Laporte Industries Ltd. announced it would expand its TiO_2 production facilities at

---

[15] U.S. Embassy, Tokyo. State Department Airgram A-210, Mar. 11, 1969.

[16] Metal Bulletin (London). No. 5323, Aug. 13, 1968, p. 21.

[17] Engineering and Mining Journal. V. 169, No. 8, August 1968, p. 134.

[18] American Cyanamid Company. Annual Report. 1968, 25 pp.

[19] Industrial Minerals (London). No. 14, November 1968, p. 34.

[20] Metal Bulletin (London). No. 5298, May 14, 1968, p. 23.

[21] Oil, Paint and Drug Reporter. V. 193, No. 4, April 1, 1968, p. 4.

Stallingborough, Lincolnshire, by 40,000 tons per year, using a chlorine process developed in cooperation with American Potash & Chemical Corp. Completion in early 1970 will make the total capacity at this location 95,000 tons per year.[22]

TECHNOLOGY

The need for titaniferous raw materials which can augment the dwindling supplies of rutile or substitute for that mineral has created considerable interest in the upgrading of ilmenite.[23] Because it takes about 2½ times as much ilmenite as it does rutile to make a unit of titanium, using the chloride process, the costs for upgrading ilmenite would have to be reduced significantly for it to compete successfully with the higher grade rutile. The major effort entailed in the several techniques developed or being developed involves increasing the TiO_2 content, up to over 90 percent in some cases, and the reduction of impurities such as an iron and chromium.

Bureau of Mines personnel endeavored to assess the feasibility of recovering certain valuable metal components found in the titanium mineral processing residues.

Also, as described in the Zirconium and Hafnium Minerals Yearbook chapter, the Bureau and industry hoped to find means for recovering marketable grades of ilmenite and rutile from Florida phosphate plant operations.

An international conference on titanium, covering all aspects of titanium research and use, was held in London in May. It was sponsored by the Institute of Metals (Great Britain), American Society for Metals, and the Metallurgical Society of the American Institute of Mining, Metallurgical, and Petroleum Engineers, in association with the Japan Institute of Metals and the Academy of Sciences of the U.S.S.R. Selected papers from the meetings were to be published in 1969 in the proceedings of the conference. Various aspects of titanium metallurgy were discussed at a Materials Engineering and Sciences conference and Exposition sponsored by the American Institute of Chemical Engineers and held in the spring of 1968.[24] Included in the 10 papers on the subject were presentations on basic metallurgy, primary production, preparation of mill products, fabrication techniques, corrosion resistance characteristics, and proven industrial applications of the metal.

At an extractive metallurgy symposium sponsored by the Metallurgical Society of AIME, held later in the year, a spokesman for TMCA described some features of a commercial prototype titanium sponge electrowinning cell.[25] The method, which involves sending an electric current through an electrolyte mixed with titanium tetrachloride in a vacuum and collecting titanium at the cathode, was said to provide a higher quality sponge and eliminate the magnesium and sodium reduction steps required in the current commercial methods. Also, an electrolytic method, which had been investigated years before, was described in detail.[26] The capital and manufacturing costs of a full scale operation to produce 20 tons of titanium per day were estimated at $28 million and $0.98 in 1959 dollars. Other papers on titanium were reported to have been presented at the 1968 Western Metal and Tool Conference and Exposition held in Los Angeles in March.[27]

An interesting property of a nickel-titanium alloy, developed by the U.S. Navy in 1961, was disclosed.[28] Called Nitinol 50 and Nitinol 60, in its two forms, the alloy is hard, nonmagnetic, corrosion-resistant, and high in tensile strength. Its unique property is the ability of the substance to regain its original shape when it is heated above its transition temperature. Measurements on the specific heat of the alloy were made.[29]

---

[22] Metal Bulletin (London). No. 5295, May 3, 1968, p. 28.

[23] Work cited in footnote 4.

[24] Defense Metals Information Center, Battelle Memorial Institute, Columbus Ohio. Titanium for the Chemical Engineer. DMIC Memorandum 234, Apr. 1, 1968, 60 pp. [available from Defense Documentation Center (DDC), Cameron Station, Bldg. 5, 5010 Duke St., Alexandria, Va. 22314].

[25] Chemical & Engineering News. Electrowinning Cell Turns Out High-Quality Titanium Sponge. V. 46, No. 54, Dec. 23, 1968, p. 32.

[26] Myhren, A. J., E. H. Kelton, R. L. Johnson, G. E. Snow, L. D. Grady, E. W. Andrews, L. J. Reimert, and C. E. Barnett. The New Jersey Zinc Company Electrolytic Titanium Pilot Plant. J. Metals, v. 20, No. 5, May 1968, pp. 38–41.

[27] Wood, R. A. Review of Recent Developments—Titanium and Titanium Alloys. Defense Metals Information Center, Battelle Memorial Institute, Columbus, Ohio, May 29, 1968, 6 pp.

[28] Product Engineering. Alloy Will Reshape Itself When Triggered by Heat. V. 39, No. 23, Nov. 4, 1968, pp. 131–132.

The experimental evaluation of titanium metal and alloys in plates for undersea vehicles and of tubing for use in aircraft was assisted by industry facility improvements. Reactive Metals, Inc. (RMI) was said to have begun producing 36-inch-diameter ingots weighing over 15,000 pounds from which it was able to make plates measuring 129 inches in diameter and 2.5 inches thick. The largest titanium plate rolled to date, by Lukens Steel Co., Coatesville, Pa., for RMI, was 151 inches in diameter and 4 inches thick and weighed 11,600 pounds. New forging facilities at Alcoa's Cleveland, Ohio, works had new heat-treatment furnaces with precise thermal controls and a rapid quenching system which insured optimum properties in large titanium forgings.

A new machining technique, which involves planning titanium extrusions by ganged tungsten carbide cutters, requires no lubricant or coolant. The method, used at Lockheed-Georgia Company's Chattanooga, Tenn. fabrication plant, affords integrally stiffened extrusions with corrosion resistance which may substitute for presently used aluminum wing panels in aircraft.[30]

Diffusion bonding techniques, that are already economic for joining large titanium aircraft forgings, were described.[31] Temperatures of between 1,675° F and 2,000° F and pressures from 14.7 pounds per square inch (psi) to 10,000 psi, employing roll bonding, blanket (up to 1,500 psi) or press bonding (up to 10,000 psi) forces an interpenetration and intermingling of atoms, with a joint at least as strong as parent metal.

Preparation methods have been investigated for borides and carbides of titanium because of the resistance of these materials to high temperatures. Titanium diboride was made by reacting titanium dioxide and elemental boron for 1 hour in a vacuum at 1,700° C.[32] Titanium carbide was deposited at high temperatures from a gas mixture of titanium tetrachloride, hydrogen, and methane.[33]

---

[29] Steel Times (London). Engineering Data Obtained for Titanium-Nickel Alloy. V. 196, No. 5, May 1968, pp. 282–283.

[30] Iron Age. Production Method Tames Titanium. V. 202, No. 24, Dec. 12, 1968, pp. 96–97.

[31] Iron Age. Bonding: Bigger and More Complex. V. 201, No. 3, Jan. 18, 1968, pp. 66–67.

Iron Age. Diffusion Bonding Goes Commercial. V. 202, No. 19, Nov. 7, 1968, pp. 64–65.

[32] Peshev, P., and G. Bliznakov. On the Borothermic Preparation of Titanium, Zirconium and Hafnium Diborides. J. Less-Common Metals, v. 14, No. 1, January 1968, pp. 23–32.

[33] Pearce, M. L., and R. W. Marek. Formation of Silicon and Titanium Carbides by Chemical Vapor Deposition. J. Am. Ceram. Soc., V. 51, No. 2, Feb. 21, 1968, pp. 84–87.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/19

Tungsten

By Richard F. Stevens [1]

Although the price of tungsten remained stabilized during the year as a result of the General Services Administration (GSA) fixed-price disposal program, the demand for tungsten fell 20 percent while mine production, as measured by mine shipments, increased 18 percent. The three major factors which continued to influence the improved world tungsten market during 1968 were, in order of importance: The price stability that occurred as a result of the U.S. Government's stockpile sales policy; the relatively high level of industrial activity in Japan, Western Europe, Eastern Europe, and the United States; and the absence of significant quantities of tungsten exports from mainland China.

Table 1.—Salient tungsten statistics

(Thousand pounds of contained tungsten)

	1964	1965	1966	1967	1968
United States:					
Mine production	W	W	W	9,250	9,817
Mine shipments	8,798	7,566	[r] 8,482	8,649	10,188
Releases from Government stocks	758	926	8,273	6,393	3,225
Exports [1]	79	11	101	974	623
Imports, general	2,737	3,495	4,203	2,004	1,824
Imports for consumption	3,148	3,618	4,298	1,699	1,743
Consumption of concentrate	12,311	13,868	18,058	13,860	11,038
Stocks:					
Producer	580	411	358	975	603
Consumer and dealer	2,090	1,434	1,582	1,134	574
World:					
Production	[r] 61,928	[r] 59,632	[r] 63,085	62,991	69,813
Consumption	58,417	60,634	65,441	58,729	56,661

[r] Revised.
W Withheld to avoid disclosing individual company confidential data.
[1] Estimated tungsten content.

Legislation and Government Programs.—During the year GSA continued its long-range tungsten concentrate disposal program and offered the tungsten concentrate in the Defense Production Act (DPA) inventory, all of which had been declared to be excess, for sale as a "shelf" item on a "first-come, first-serve basis." Sales continued to be made at $43 per short-ton unit (s.t.u.) adjusted for premiums and penalties and some 3¼ million pounds, tungsten content, were released in 1968 at an average adjusted price of $40.05 per s.t.u. The average adjusted prices of individual sales ranged from $37.27 to $43.63 per s.t.u. There continued to be no restrictions on the exportation of this material and approximately 20 percent was purchased by traders for export. The companies which purchased excess tungsten during the year are listed below:

---

[1] Physical scientist, Division of Mineral Studies.

Company	Amount (s.t.u.)	Dollar value	Average price ($/s.t.u.)
Firth Sterling	46,293	$1,802,549	$38.94
Union Carbide Corp	3,574	134,349	37.59
W. R. Grace & Co	4,297	187,441	43.63
Philipp Brothers Corp., Inc	76,747	3,053,204	39.78
Bethlehem Steel Corp	3,554	146,007	41.08
VASCO	1,818	72,833	39.95
Fansteel Inc. (formerly Fansteel Metallurgical Corp.)	14,358	583,410	40.63
Columbia Tool Steel Co	3,453	139,974	40.54
Kennametal, Inc	36,371	1,483,443	40.79
Sylvania Electric Products, Inc	3,156	137,329	43.51
Molybdenum Corporation of America (Molycorp)	2,252	91,709	40.72
Shieldalloy Corp	503	21,122	41.99
General Electric Co	3,153	137,397	43.58
C. Tennant & Sons	3,782	152,692	40.37
Total	203,311	$8,143,459	$40.05

A detailed report was prepared for GSA to help that agency formulate its continuing plans for long-range disposal programs of excess tungsten concentrate.[2]

Table 2.—U.S. Government tungsten materials inventories and objectives

(Thousand pounds, tungsten content)

Material	Objective	Inventory by program Dec. 31, 1968			Total
		National (strategic) stockpile	DPA	Supplemental stockpile	
Tungsten ore and concentrate:					
Stockpile grade	35,785	67,541	43,981	3,352	114,874
Nonstockpile grade	--------	46,695	15,724	1,153	63,572
Ferrotungsten:					
Stockpile grade	1,800	938	--------	--------	938
Nonstockpile grade	--------	1,203	--------	--------	1,203
Tungsten metal powder, hydrogen reduced:					
Stockpile grade	1,600	1,196	--------	--------	1,196
Nonstockpile grade	--------	102	--------	--------	102
Tungsten metal powder, carbon reduced:					
Stockpile grade	500	547	--------	--------	547
Nonstockpile grade	--------	171	--------	--------	171
Tungsten carbide powder:					
Stockpile grade	2,000	842	--------	1,080	1,922
Nonstockpile grade	--------	112	--------	--------	112
Tungsten carbide, crystalline:					
Stockpile grade	1,100	--------	--------	--------	--------

DOMESTIC PRODUCTION

Ore and Concentrate.—As a result of the Government's continuing disposal policy which resulted in high stabilized prices during 1968, domestic production as measured by mine shipments increased 18 percent. Although 47 mines reported production and/or shipments of tungsten concentrates during the year, only the Pine Creek mine of the Mining and Metals Division, Union Carbide Corp., near Bishop, Calif., and the Climax mine of Climax Molybdenum Co., a division of American Metal Climax, Inc., (AMAX), at Climax, Colo., operated con-

---

[2] Charles River Associates Inc. Economic Analysis of the Tungsten Industry. Cambridge, Mass., January 1969, 314 pp.

Table 3.—Tungsten concentrate shipped from mines in the United States

Year	Quantity			Reported value f.o.b. mines [1]		
	Short tons, 60 percent WO_3 basis	Short-ton units WO_3[2]	Tungsten content (thousand pounds)	Total (thousands)	Average per unit of WO_3	Average per pound of tungsten
1964	9,244	554,676	8,798	$11,251	$20.28	$1.28
1965	7,949	476,979	7,566	13,028	27.32	1.72
1966	8,912	534,727	8,482	17,620	32.95	2.08
1967	9,088	545,269	8,649	20,895	38.32	2.42
1968	10,704	642,263	10,188	25,197	39.23	2.47

[1] Values apply to finished concentrate and are in some instances f.o.b. custom mill.
[2] A short-ton unit equals 20 pounds of tungsten trioxide (WO_3) and contains 15.862 pounds of tungsten.

tinuously during 1968. Both of these mines obtained tungsten as a coproduct or byproduct. Tungsten was the major mineral value recovered at Pine Creek along with minor amounts of molybdenum, copper, and gold. At Climax, the major mineral value recovered was molybdenum while tungsten, tin, pyrite, and monazite were recovered as byproducts.

Additional intermittent tungsten output was also reported from Pima, Santa Cruz, and Yuma Counties, Ariz.; Fresno, Inyo, Kern, Madera, San Bernardino, Tulare, and Tuolomne Counties, Calif.; Boulder and Lake Counties, Colo.; Custer and Valley Counties, Idaho; Beaverhead, and Deer Lodge Counties, Mont.; Churchhill, Ormsby, Pershing, and White Pine Counties, Nev.; and Salt Lake County, Utah. Some of these mines, because of their high elevation, were able to operate for only about 6 months of the year when the area was relatively clear of snow.

Ranchers Exploration & Development Corp., Albuquerque, N. Mex., completed an evaluation of the tungsten ore reserves and the production potential of the Hamme tungsten mine near Henderson, N.C., and late in the year it was announced that Ranchers had purchased this property from Howmet Corp. Ranchers indicated that it had completed pumping the water which had filled the mine following its closing in early 1963, that a main shaft was being sunk, and that the company was reviewing the extractive metallurgical operations involved to determine the most economic methods for use at this site. Plans were underway to replace the equipment which had been sold at auction following closure of the mine and to build a processing mill adjacent to the mine site. This property is not expected to be in full-scale production before 1970 at which time, based upon historical data, the Hamme mine could produce between 1¾ to 2½ million pounds of contained tungsten annually. This would make Ranchers the second largest domestic tungsten producer.

During the year Union Carbide Corp. obtained an option to purchase the Leonard scheelite mine near Rawhide, Nev., from Kennametal, Inc. This mine reportedly has important reserves of medium-grade scheelite ore. Low-grade concentrate could easily be trucked to Union Carbide's Pine Creek synthetic scheelite processing facilities for upgrading to commercial grade concentrate.

Minerals Engineering Co., with financial assistance from General Electric Co., continued work on the reopening of its Calvert Creek open-pit tungsten mine in Montana. In connection with this operation, the capacity of the mill in Glen, Mont., is being increased to 250 tons per day (tpd) and a chemical processing plant is being constructed to process the concentrate to ammonium paratungstate (APT). This operation, which was originally scheduled to go on stream in 1968, has been delayed by corrosion problems in the solvent extraction circuits of the APT plant and it is not expected that full production will begin before mid-1969. It is anticipated that most of the output will be shipped to General Electric.

Because of heavy snows, tungsten production at the Strawberry mine of the New Idria Mining & Chemical Co., Madera County, Calif., was limited to only 5 to 6 months' operation during the year; while the Eureka tungsten mine of Canyon Mining Corp., near Boulder, Colo., was able to operate throughout the year owing to its close proximity to an all-weather highway.

Metal, Alloys, and Compounds.—The Chemical and Metallurgical Division of Sylvania Electric Products, Inc., continued further expansion of its facilities at Towanda, Pa., with the completion of a 63,000-square-foot addition to its metals plant. This new structure will permit the expansion and consolidation of tungsten and molybdenum rod, wire, and fabricated parts production formed from arc-melted metal ingots.

Carbide, Inc., McKeesport, Pa., developed a method of isostatic pressing tungsten carbide powder which gives superior control over size, uniformity, and properties than that obtainable by standard hydraulic pressing operations.

M&R Refractory Metals, Inc., Springfield, N.J., was acquired during the year by Whittaker Corp., Los Angeles, Calif., to expand the latter's metal processing activities by adding chemical processing techniques to existing pyro-metallurgical methods. M&R will be operated under its former management as a subsidiary of Whittaker's Industrial and Commercial Metals Group.

During the year Firth-Loach Metals, Inc., a cemented carbide producer, was acquired by Howmet Corp. and became the Carbide Division of the Howmet Superalloy Group.

In 1968 Fansteel Metallurgical Corp. changed its name to Fansteel Inc. because the old name was inadequate to describe the company's broadened involvement in a wide variety of organic, ceramic, and special metals and materials technologies.

Carmet Co., a subsidiary of Allegheny Ludlum Steel Corp., announced that it had purchased a 42,000-square-foot plant at Shinnston, W. Va., for use as a tungsten carbide manufacturing facility.

Metal Carbides Corp., Youngstown, Ohio, announced plans for a $500,000 expansion of its present plant. A new building will be built to house the additional equipment needed to increase the company's output of tungsten carbide, about 15 percent of which is exported to Japan and Western Europe.

CONSUMPTION AND USES

The major individual end use of tungsten during 1968 continued to be as tungsten carbide (WC) which accounted for 40 percent of the total consumption. Consumption of other tungsten products was as follows: Tungsten metal powder (28 percent), ferrotungsten (12 percent), and scheelite and scrap (18 percent). In addition, a small quantity, less than 2 percent, of tungsten was used in the form of tungsten chemicals. Tungsten carbides were produced from tungsten metal powder and from tungsten scrap. Ferrotungsten and scheelite were used as additives in steelmaking and tungsten wire and wrought products were produced from high-purity tungsten metal powder.

World consumption of tungsten is expected to grow at an average rate of over 9 percent annually through 1975 according to a forecast made by the president of American Metal Climax, Inc. (AMAX).

Mallory Metallurgical Products, a joint subsidiary of Johnson Matthey Metals and P. R. Mallory & Co., Indianapolis, Ind., has developed and is offering a high-melting-point, tungsten-base alloy produced by powder metallurgy techniques for use as a pressure die casting tool material. Designated Anviloy, this alloy requires no heat treatment and has outstanding resistance to heat fatigue.

The Coromant Division of Sandvik Steel Inc., Fair Lawn, N.J., developed a new grade of tungsten carbide designed especially for semiroughing and finish turning of super alloys. The high edge strength and wear resistance of this tungsten carbide, designated Rl Premium, make the material especially suitable for these operations.

Several special reviews were published that discussed and evaluated the tungsten supply-demand patterns, and the high-temperature aerospace and other applications of this metal.[3] A review and outlook of ferroalloy additive materials was published which discusses the use of tungsten as a ferroalloy material.[4]

---

[3] Metals Week. Clad Metals: The Best of All Possible Worlds. V. 39, No. 1, Jan. 1, 1968, pp. 10–18. Ruth, John P. Space Age Metals Section. American Metal Market, sec. 2, v. 75, No. 98, May 21, 1968, 16 pp.

[4] Metals Week. The Ferroalloy Metals, Review '67–Outlook '68. V. 39, No. 10, Mar. 4, 1968, 24 pp.

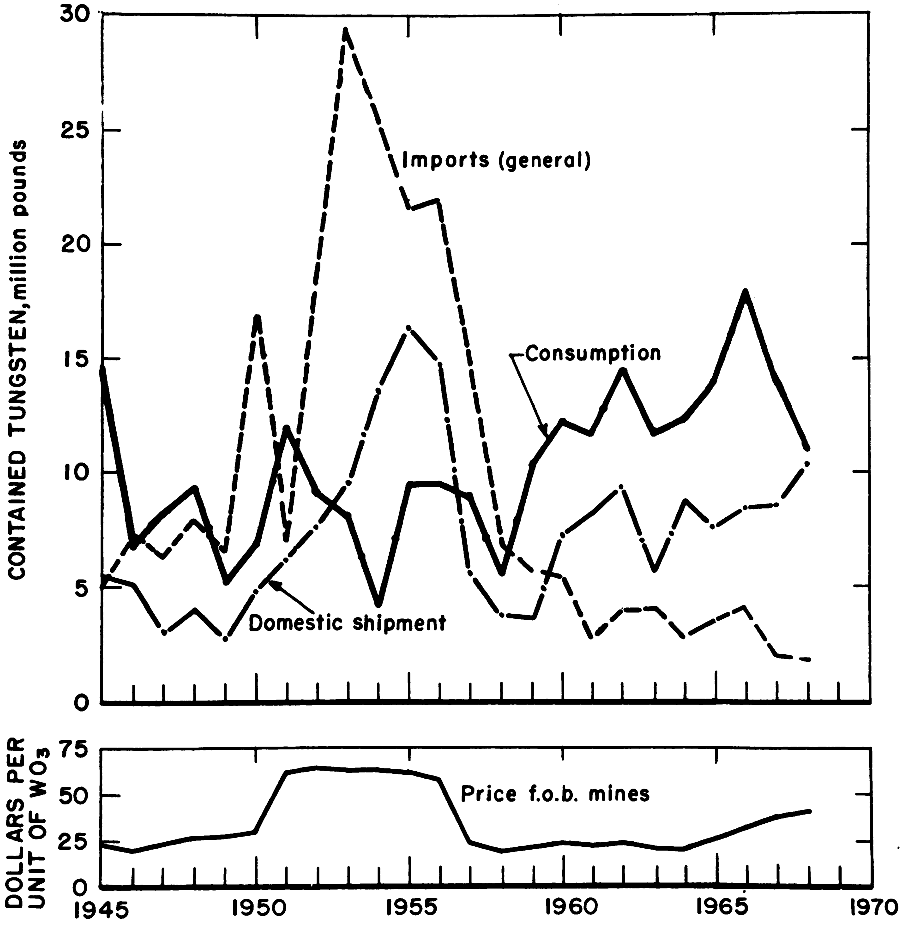

Figure 1.—Domestic shipments, imports, consumption, and average price of tungsten ore and concentrate.

PRICES AND SPECIFICATIONS

Throughout 1968 the domestic price of tungsten ore and concentrate was quoted at $43 per short-ton unit. The world price as quoted in Metals Week and in the Metal Bulletin (London) remained near the GSA sales price of $43 per short-ton unit. The GSA sales policy continued to have a stabilizing effect on the world tungsten price which had been subject to extremely wide fluctuations prior to its inception in 1966. During the year the average monthly London price approached or exceeded "parity" (the price at which tungsten on the Western European market was sold at or above that of GSA ($43)) only nine times. Twice during the year, in May and October, the European (London) price fell in anticipation of the Canton (China) Trade Fairs. However, in both cases, as in previous years, very little tungsten was reportedly purchased at these fairs, and the price quotations were quick to respond.

The price of ammonium paratungstate (APT) processed from domestic ore and delivered to contract customers reportedly ranged from $39 to $45 per short-ton unit.

Table 4.—Production, shipments, and stocks of tungsten products in the United States

(Thousand pounds of contained tungsten)

	Hydrogen- and carbon reduced metal powder	Tungsten carbide powder		Chemicals	Other [1]	Total [2]
		Made from metal powder	Crushed and crystalline			
1967						
Gross production during year	9,256	5,549	2,714	11,606	1,785	30,910
Used to make other products listed here	6,725	--------	--------	10,246	1,334	18,306
Net production	2,531	5,549	2,714	1,360	450	12,604
Shipments [3]	7,487	5,690	2,773	6,436	1,738	24,124
Producer stocks, December 31	2,125	201	756	1,777	309	5,168
1968						
Gross production during year	7,702	4,458	2,472	10,542	2,423	27,597
Used to make other products listed here	5,349	--------	--------	9,934	1,776	17,059
Net production	2,353	4,458	2,472	608	646	10,538
Shipments [3]	7,191	4,457	2,712	6,313	2,452	23,125
Producer stocks, December 31	1,812	228	776	1,621	314	4,747

[1] Includes ferrotungsten, scheelite (produced from scrap), nickel-tungsten, self-reducing oxide, pellets, and scrap.
[2] Data may not add to totals shown because of independent rounding.
[3] Includes quantities consumed by producing firms for manufacture of products not listed here.

Table 5.—Consumption, by end uses, and stocks of tungsten products in the United States in 1968

(Thousand pounds of contained tungsten)

Use	Ferro-tungsten [1]	Tungsten metal powder [2]	Tungsten carbide powder	Other tungsten materials [3]	Total [4]
Steel (ingots and castings):					
High speed and tool	952	--------	--------	1,018	1,970
Stainless	140	--------	--------	61	201
Alloy (excluding stainless)	200	W	W	122	322
Other steel	W	--------	--------	97	97
Cast irons	(5)	--------	--------	63	63
Cutting and wear resistance materials:					
Cemented or sintered carbides	------	834	4,012	215	5,060
Other	(5)	38	31	35	104
Welding and hard facing rods and materials	8	391	534	228	1,155
Nonferrous alloys	160	305	--------	218	678
Electrical materials	(5)	104	W	27	131
Chemical and ceramic uses:					
Pigments	------	--------	--------	141	141
Other	------	W	--------	221	221
Miscellaneous and unspecified	91	1,941	672	259	2,963
Total [4]	1,552	3,612	5,248	2,695	13,108
Consumer stocks December 31, 1968	367	669	510	818	2,364

W Withheld to avoid disclosing individual company confidential data, included in "Miscellaneous and unspecified."
[1] Includes melting base and metal pellets.
[2] Includes both carbon-reduced and hydrogen-reduced tungsten metal powder.
[3] Includes tungsten chemicals, natural and synthetic scheelite, tungsten scrap, and other.
[4] Data may not add to totals shown due to individual rounding.
[5] Less than ½ unit.

APT processed from GSA material was believed to be sold in the range from $48 to $51 per short-ton unit.

The quoted prices of the various grades of ferrotungsten in lots of 5,000 pounds or more, ¼-inch lump, packed, f.o.b. destination, continental United States, 70 to 80 percent tungsten, increased from a range of $2.03 to $3.50 per pound, tungsten content, at the beginning of 1968 to a range of $3.20 to $3.71 per pound, tungsten content, at yearend. The quoted price of UCAR, Union Carbide's special high-grade ferrotungsten rose from $2.03 per pound, tung-

Table 6.—Monthly price quotations of tungsten concentrate in 1968

Month	Wolfram and scheelite: London market, shilling per long-ton unit of WO_3, 60 percent basis:		Equivalent quotation, dollars per short-ton unit of WO_3		
	Low	High	Low	High	Average [1]
January	405	425	$43.41	$45.55	$44.48
February	397½	427½	42.60	45.82	44.21
March	350	422½	37.51	45.28	41.93
April	295	352	31.62	37.73	34.73
May	290	330	31.08	35.37	33.01
June	320	367½	34.30	39.39	36.66
July	357½	415	38.32	44.48	41.91
August	395	415	42.34	44.48	43.41
September	377½	415	40.46	44.48	43.03
October	350	390	37.51	41.80	39.23
November	355	422½	38.05	45.28	41.37
December	410	450	43.94	48.23	46.62

[1] Arithmetic average of weekly quotations. Average equivalent price $40.88; duty $7.14; average equivalent price, duty paid, $48.02.

sten content, at the beginning of the year to $3.71 per pound tungsten content, at yearend.

The quoted prices of both carbon- and hydrogen-reduced tungsten metal powder remained unchanged during the year. Carbon-reduced tungsten metal powder (99.8 percent in 1,000-pound lots) was quoted by Metals Week at $2.75 per pound of contained tungsten. The quoted price of hydrogen-reduced tungsten metal powder (99.99 percent) continued to range from $4.60 to $5.44 per pound.

While not quoted, the price of scheelite for direct addition to steel melts was believed to be about $35.50 per short-ton unit, equivalent to about $2.20 per pound of contained tungsten.

The price of pressed and sintered tungsten billets ranged from $15.44 per pound for billets 1 inch in diameter to $8.00 per pound for 10-inch-diameter billets. Tungsten rod (99.95 percent) was offered in the price range from about $9.65 to $34.60 per pound, depending upon diameter grain size and finished surface condition. The price of tungsten sheet ranged from about $18.33 to $92.50 per pound, depending upon quantity, thickness and size.

The price of tungsten chemicals ranged from $3 to $45 per pound, depending upon amount and type of chemical.

A summary of a French doctoral thesis, "The Formation of the Price of Tungsten on the World Market," was published in English.[5]

FOREIGN TRADE

Exports of tungsten concentrate (table 7) decreased 36 percent in 1968 and represented material purchased from the GSA stockpile. Reexports, of tungsten ore and concentrate, all to West Germany totaled 112,000 pounds gross weight, valued at $117,429.

Exports of unwrought tungsten metal and alloys in crude form, waste, and scrap, primarily to West Germany, decreased 12 percent to 593,092 pounds, gross weight, valued at $727,100 in 1968. Tungsten and tungsten alloy powder exports decreased 8 percent during the year to 46,908 pounds, gross weight, valued at $220,984 and were shipped primarily to West Germany (48 percent) and Canada (31 percent).

Tungsten and tungsten alloy wire exports, primarily to Canada (43 percent) and Brazil (22 percent), rose 42 percent to 51,794 pounds, gross weight, valued at $1,524,162 in 1968. Exports of wrought tungsten and tungsten alloys primarily to West Germany (48 percent), and Canada (36 percent), almost doubled during the year and totaled 71,189 pounds, gross weight, valued at $766,012.

During the year general imports of tungsten concentrate decreased 9 percent while imports for consumption rose 3 percent. As in the previous 4 years, there were no duty-

---

[5] Mining Magazine (London). The World's Tungsten Economy. V. 117, No. 6, December 1967, pp. 461–466.

Table 7.—U.S. exports of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1967			1968		
	Gross weight	Estimated tungsten content [1]	Value	Gross weight	Estimated tungsten content [1]	Value
Austria	-------	-------	-------	106	55	$141
Belgium-Luxembourg	107	55	$161	-------	-------	-------
Canada	16	8	13	90	47	133
France	153	79	247	83	43	111
Germany, West	127	66	262	485	250	687
Japan	304	157	393	119	61	169
Netherlands	458	236	749	29	15	43
South Africa, Republic of	477	246	744	-------	-------	-------
United Kingdom	246	127	[r] 365	295	152	421
Total	1,888	974	[r] 2,934	1,207	623	1,705

[r] Revised.

[1] Tungsten content estimated by multiplying the gross weight by a factor of 0.516 equal to 0.65 (to convert from 65 to 100 percent WO_3 basis) times 0.7931 (to convert from WO_3 to W basis).

free imports of tungsten ore and concentrate for the U.S. Government during 1968.

Imports of tungsten carbide during the year, primarily from Sweden (73 percent), West Germany (13 percent), and the United Kingdom (12 percent), increased by a factor of 8 to 14,984 pounds, tungsten content, valued at $86,343. There were no imports of semifabricated tungsten in ingots and shot during the year.

Imports of tungsten waste and scrap containing over 50 percent tungsten decreased significantly in 1968 to 26,889 pounds, tungsten content, valued at $36,247, primarily from Sweden (48 percent). Imports of unwrought tungsten in lump, grains, and powder continued to decrease in 1968 and totaled only 2,711 pounds tungsten content, valued at $19,486, almost all from France. In 1968 imports of wrought tungsten increased 18 percent to 6,161 pounds, valued at $316,084. This material came primarily from Austria (40 percent) and the Netherlands (18 percent).

Imports of calcium tungstate during 1968, almost all from West Germany, totaled 12,539 pounds, tungsten content, valued at $86,891, a 17-percent increase over 1967 imports.

Imports of material classified as other metal-bearing materials in chief value tungsten decreased significantly and totaled only

Table 8.—U.S. imports [1] of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1967			1968		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	336	195	$508	266	145	$297
Bolivia	156	90	206	109	55	73
Burundi and Rwanda	-------	-------	-------	11	4	11
Canada	739	463	871	1,610	1,035	1,928
Chile	-------	-------	-------	15	9	21
Congo (Kinshasa)	132	68	138	-------	-------	-------
Hong Kong	-------	-------	-------	5	2	4
Korea, South	560	316	639	-------	-------	-------
Mexico	23	12	16	3	2	2
New Zealand	20	11	35	-------	-------	-------
Peru	635	369	848	874	506	961
Portugal	806	480	1,175	67	40	91
United Kingdom [2]	-------	-------	-------	45	26	56
Total	3,407	2,004	4,436	3,005	1,824	3,444

[1] Data are "general imports", that is, they include tungsten imported for immediate consumption plus material entering the warehouses.

[2] Represents transshipment, rather than country of origin.

Table 9.—U.S. imports for consumption of tungsten ore and concentrates, by countries

(Thousand pounds and thousand dollars)

Country	1967			1968		
	Gross weight	Tungsten content	Value	Gross weight	Tungsten content	Value
Australia	296	172	$445	134	73	$146
Bolivia	156	90	206	109	55	73
Burundi and Rwanda	-------	-------	-------	11	4	11
Canada	739	463	871	1,610	1,035	1,928
Chile	-------	-------	-------	(1)	(1)	(1)
Congo (Kinshasa)	132	68	138	-------	-------	-------
Hong Kong	-------	-------	-------	5	2	4
Korea, South	60	34	50	-------	-------	-------
Mexico	23	12	16	3	2	2
New Zealand	20	11	35	-------	-------	-------
Peru	635	369	848	874	506	961
Portugal	806	480	1,175	67	40	91
United Kingdom [2]	-------	-------	-------	45	26	56
Total	2,867	1,699	3,784	2,858	1,743	3,272

[1] Less than ½ unit.

[2] Represents transshipment, rather than country of origin.

Table 10.—U.S. imports for consumption of tungsten or tungsten carbide forms

(Thousand pounds and thousand dollars)

Year	Ingots, shot, bars, and scrap		Wire, sheets, or other forms, n.s.p.f.		Total	
	Quantity	Value	Quantity	Value	Quantity	Value
1966	292	$432	49	$208	341	$640
1967	138	246	5	277	143	523
1968	44	51	6	316	50	367

Table 11.—U.S. import duties on all forms of tungsten (tungsten content)

(Per pound contained tungsten)

Tariff classification	Article	Rate of duty [1] Effective Jan. 1, 1968	Rate of duty [1] Effective Jan. 1, 1969
601.54	Tungsten ore	$0.45 per pound tungsten (W)	$0.40.
608,45	Other metal bearing materials in chief value tungsten.	$0.375 plus 18 percent ad valorem.	$0.335 plus 16 percent ad valorem.
607.65	Ferrotungsten	$0.378 plus 11 percent ad valorem.	$0.335 plus 10 percent ad valorem.
629.25	Waste and scrap containing by weight not over 50 percent tungsten.	do	$0.33 plus 10 percent ad valorem.
629.26	Waste and scrap containing by weight over 50 percent of tungsten.	18.5 percent ad valorem	16.5 percent ad valorem.
629.28	Unwrought tungsten, except alloys, in lump, grain, and powder.	$0.37 plus 22.5 percent ad valorem.	$0.33 plus 20 percent ad valorem.
629.29	Unwrought tungsten ingots and shot.	18.5 percent ad valorem	16.5 percent ad valorem.
629.30	Unwrought tungsten, n.e.c	22.5 percent ad valorem	20 percent ad valorem.
629.32	Tungsten alloys, unwrought, containing by weight not over 50 percent tungsten.	$0.378 plus 11 percent ad valorem.	$0.335 plus 10 percent ad valorem.
629.33	Tungsten alloys, unwrought, containing by weight over 50 percent tungsten.	22.5 percent ad valorem	20 percent ad valorem.
629.35	Wrought tungsten	do	Do.
416.40	Tungstic acid	$0.37 plus 18 percent ad valorem.	$0.33 plus 16 percent ad valorem.
417.40	Ammonium tungstate	do	Do.
418.30	Calcium tungstate	do	Do.
420.32	Potassium tungstate	do	Do.
421.56	Sodium tungstate	do	Do.
422.40	Tungsten carbide	$0.378 plus 22 percent ad valorem.	$0.33 plus 20 percent ad valorem.
422.42	Other tungsten compounds, n.e.c.	$0.37 plus 18 percent ad valorem.	$0.33 plus 16 percent ad valorem.
423.92	Mixtures of two or more inorganic compounds in chief value tungsten.	do	Do.

[1] Not applicable to Communist countries.

4,961 pounds, tungsten content, valued at $8,097 in 1968. This material, believed to represent primarily synthetic scheelite, was all received from Japan. As in 1967, there were no imports of ferrotungsten during the year.

In accordance with the completed Kennedy Round Tariff Negotiations, the import duties on all forms of tungsten were further reduced, effective January 1, 1969, as indicated in table 11.

WORLD REVIEW

The United Nations Committee on Tungsten continued its collection of statistical, scientific, technical, and economic data on tungsten and conducted a review of the world tungsten situation through its eight-member (Australia, Austria, Bolivia, Portugal, South Korea, Sweden, the United States, and West Germany) subcommittee, the Working Group. This body met in New York in September, but because of the continued favorable state of the world tungsten market, a meeting of the full committee was not held during 1968.

In addition to its regular quarterly report, "Tungsten Statistics," the Committee issued during the year, a new publication, "Tungsten Bibliography," which listed scientific, technical, and economic reports on tungsten. Copies of both of these periodic reports are available upon request, from the United Nations Conference on Trade and Development (UNCTAD), Distribution Section, Palais des Nations, Geneva, Switzerland.

At its September meeting the Working Group discussed the possibility of recom-

Table 12.—World production of tungsten ore and concentrate, by countries[1]

(Thousand pounds of contained tungsten)[2]

Country	1964	1965	1966	1967	1968 [p]
North America:					
Canada [3]	840	2,964	[r] 3,296	[e] 220	2,855
Guatamala	--------	--------	9	88	13
Mexico	8	192	150	828	586
United States (shipments)	8,798	7,566	8,482	8,644	10,188
South America:					
Argentina	64	152	[r] 152	232	NA
Bolivia	2,106	1,912	[r] 2,760	3,494	4,000
Brazil	402	402	[r] 494	638	958
Peru	676	836	762	871	1,120
Europe:					
Austria	110	206	144	150	[e] 236
Portugal	1,854	1,724	2,096	2,416	2,855
Spain	[r] 35	49	[r] 106	166	245
U.S.S.R. [e]	11,400	12,600	13,000	13,600	13,600
Africa:					
Congo (Kinshasa)	244	224	[r] 200	116	86
Rwanda	156	288	432	611	708
South-West Africa, Territory of	198	178	186	[e] 187	[e] 187
Tanzania	--------	--------	7	50	20
Uganda	--------	50	[r] 75	84	[e] 88
Asia:					
Burma	600	[r] 350	240	338	307
China, mainland [e]	21,400	17,600	17,600	17,600	17,600
Japan	910	758	724	862	1,165
Korea:					
North [e]	4,200	[r] 4,200	4,720	4,720	4,720
South	5,698	4,698	[r] 4,533	4,464	4,615
Malaysia	[r] 9	[r] 11	4	33	143
Thailand	452	[r] 582	[r] 591	956	988
Oceania:					
Australia	1,768	2,090	2,322	2,123	2,530
Total [4]	[r] 61,928	[r] 59,632	[r] 63,085	62,991	69,813

[e] Estimate. [p] Preliminary. [r] Revised.

[1] France, Sweden, and Yugoslavia are no longer tungsten producers. In addition, the following countries also produce tungsten (only 1 to 15 short tons of contained tungsten yearly each): Hong Kong, India, Italy, Mongolia, New Zealand, Nigeria, Republic of South Africa, [illegible]

[2] Conversion factors: WO_3 to W equals 0.7931; in converting 60 percent WO_3 concentrate to W, multiply by 0.4758.

[3] Only producer was shut down in December 1966 and was reopened in December 1967.

[4] Total is of listed figures only.

Table 13.—World consumption of tungsten ore and concentrate, by countries[1]

(Thousand pounds, tungsten content)

	1964	1965	1966	1967	1968 [p]
Actual consumption:					
Australia [e]	110	110	110	110	110
Austria	[2] 3,909	3,982	[r] 4,190	3,140	2,820
Canada	286	447	449	405	[3] 400
Japan	4,910	[r] 3,240	4,002	5,740	4,990
Portugal	651	433	341	688	524
United Kingdom	[2] 7,447	7,515	6,633	4,880	5,920
United States	12,811	13,868	18,058	13,860	11,038
Apparent consumption, including stock variations:					
France	1,846	2,636	[r] 3,045	2,320	1,965
Sweden	1,549	2,162	2,072	1,350	[3] 1,100
Apparent consumption, excluding stock variations:					
Argentina	59	117	[r] 93	[r] 110	[3] 100
Belgium-Luxembourg	2	44	[r] 64	55	[3] 55
China (mainland)[3]	1,050	1,050	1,050	1,250	1,300
Germany, West	4,992	6,280	[r] 5,480	4,420	5,630
Italy	106	15	42	[r] 20	--------
Korea, North [3]	3,500	3,500	3,500	3,500	3,500
Netherlands	79	319	574	[r] 286	284
Poland	[r] 3,230	2,720	[r] 3,445	[r] 2,825	[3] 2,900
Spain	[r] 29	--------	[r] 181	170	[3] 150
U.S.S.R.[3]	12,000	12,000	12,000	13,600	13,750
Yugoslavia	350	[e] 198	[r] 112	--------	[3] 125
Total	[r] 58,417	[r] 60,634	[r] 65,441	58,729	56,661

[e] Estimate. [p] Preliminary. [r] Revised.

[1] In addition, the following countries are known or believed to consume tungsten but specific data are not available: Brazil, Bulgaria, Chile, Czechoslovakia, Denmark, Finland, Germany (East), Hungary, India, Israel, Norway, Republic of South Africa, Rumania, Switzerland.

[2] Apparent consumption.

[3] Estimated by author of chapter.

mending to the Committee on Tungsten the enlargement of the group from eight to 12 countries. Because the suggested expanded membership of the Working Group would include all the major producing and consuming countries who are U.N. members, the group would be more responsive to activities concerning tungsten. Thus, the desires of the major governments interested in tungsten could be discussed in the absence of full committee meetings.

Algeria.—Exploration of the Laoumi tungsten deposit, located about 45 miles southeast of Tamaurassa, was conducted during the year under a jointly sponsored Algerian–U.S.S.R. development fund.

Argentina.—Tungsten ore deposits continued to be worked, almost entirely for exports, in the provinces of Cordoba, Rio Negro, and San Luis. At yearend the country's commercial tungsten reserves were estimated to total 643,000 tons.

Australia.—The country's growing tungsten production continued to come from three operations; two were byproduct operations located in Tasmania and one was a scheelite mine located on King Island. Australia is estimated to have from 38 to 40 million pounds, tungsten content, of economically minable reserves. Exploration by King Island Scheelite (1947) Ltd. revealed additional reserves of almost 3 million tons averaging 0.53 percent WO_3. These reserves were located about 2 miles from the present open pit operation.

Endurance Mining Corp. evaluated its scheelite deposit about 20 miles from Tamworth in New South Wales. Preliminary drilling indicated the presence of minable grade material containing between 0.8 and 1.44 percent WO_3.

A detailed evaluation of recent developments in Australian tungsten recovery operations was published during the year which described the flowsheets, extractive metallurgical operations, equipment, and reagents employed.[6]

The Australian Tariff Board was consulted by the Minister for Trade and Industry to determine whether assistance, in the form of tariffs, should be accorded to Australian tungsten carbide producers and, if so, what the nature and extent of this assistance should be. In previous years the United States has been a significant supplier of tungsten carbide to Australia.

---

[6] Woodcock, J. T. Ore Dressing Developments in Australia, 1967. Australian Mining, Melbourne, Australia, v. 60, No. 7, July 15, 1968, pp. 46–91.

Titan Manufacturing Co. Pty. Ltd., a wholly owned subsidiary of Broken Hill Pty. Co. Ltd., operates the country's major tungsten carbide plant at Newcastle, New South Wales.

Canada.—Canada Tungsten Mining Corp. Ltd. (CTMC), the country's only tungsten producer, resumed full-scale production of high-grade scheelite at its mine and mill at Tungsten (formerly Flat River), Northwest Territories, following reconstruction of the mill and crusher house which had been destroyed by fire in December 1966.[7] During reconstruction, the mill capacity was increased to 350 tons per day to handle the increased production anticipated in the future.

Mine production totaled 180,000 short tons units of WO_3 as mining was confined to the summer months.[8] A total of 116,558 tons of ore containing an average of 1.98 percent WO_3 was treated at the new concentrator during the year, giving an overall scheelite recovery of 77.74 percent. Output fell during the last quarter of the year when ore feed having a hardness greater than anticipated was encountered. To rectify this problem a secondary ball mill was installed in the grinding circuit in December. At yearend reserves of tungsten ore in place were estimated at 813,893 tons averaging 1.61 percent WO_3. Stockpiled ore totaled 105,119 tons averaging 1.81 percent WO_3.

Operation of the company's leach plant in North Vancouver, British Columbia, began again in January when material from the mine site was available and raw concentrate was upgraded from an average of 31 percent WO_3 to 68 percent WO_3 by acid dissolution of contained calcite.

Drilling and geological examination of high-grade tungsten ore in the Jennings Lake area of British Columbia, about 75 miles southwest of Watson Lake, Yukon Territory, revealed sufficient ore to warrant the development of an open-pit mine by Spartan Exploration Ltd. Burnt Hill Tungsten & Metallurgical Ltd., Montreal, continued exploration of its tungsten property in York County, New Brunswick, and late in the year entered into a cooperative agreement with Stalco (The Steel Company of Canada Ltd.) whereby the latter would provide financial backing for development work and construction of a mill if the existence of a commercial tungsten ore deposit is established. Under this agreement all resulting production would be marketed exclusively by Stalco.

China, mainland.—While no official published information is available on the tungsten industry of mainland China, it was estimated that the country's reserves and resources total more than 13 billion pounds, tungsten content. About 70 percent of the country's tungsten ore production comes from large deposits in Kiangsi Province which are believed to average about 1.1 percent WO_3. Although some of the deposits in this area were once reported to be the richest in the world, most of the high-grade material is believed to have been mined. About 25 percent of the country's output was produced in the provinces of Huran and Kwantung. Although tungsten deposits are known to exist in the provinces of Hopei, Fukien, and Kwangsi, the output was believed to be low. Because of lack of mechanization, it was estimated that some 60,000 to 80,000 workers were employed in the tungsten mines, primarily as miners and hand sorters. The tungsten ores are treated at metallurgical processing works in Kan-chou, Nan-chang, and Chy-chou.

About 7 to 10 percent of the country's tungsten production was believed to be consumed domestically. The remainder, in the form of high-grade (66 to 68 percent WO_3) wolfram concentrate, was believed to be exported primarily to other Communist Bloc (Eastern European) countries, and to a lesser extent, to some Western European countries and Japan.

Two grades of tungsten concentrate reportedly are recovered from wolframite ores; Grade 1 contains a maximum of 0.2 percent tin, while Grade 2 contains a maximum of 1.5 percent tin. Although China also reportedly produces two grades of scheelite concentrate, the impurities, primary molybdenum, are high and extremely variable making this material generally unacceptable in world markets.

France.—Development of the scheelite deposit at Salau, in southern France, continued as an access road to the site was completed and construction of the processing plant was initiated. Production from this mine will be marketed by Omnium des Mines, the major shareholder.

---

[7] Western Miner. Canada Tungsten Resumes Operations. V. 40, No. 12, December 1967, pp. 46–47.

[8] Canada Tungsten Mining Corp. Ltd. Annual Report 1968. Toronto, Canada, Mar. 28, 1969, 9 pp.

Germany, West.—Effective July 1, 1968, the activities of Ciba Rare Metals, a division of Ciba Ltd., Basle, Switzerland, were transferred to the West German metal processing firm, Hermann C. Starck, Berlin. Products of the former Ciba Rare Metals Division will continue to be manufactured at the plant in Basle.

India.—The four producing tungsten mines, at Rewat Hill, Nagpur district, Rajasthan; at Agargaon, Nagpur district, Maharashtra; at Kalimati, Singhbhum district, Bihar; and at Chhendapathar, Bankura district, West Bengal, were described.[9] An evaluation of methods of producing ferrotungsten and tungsten powder from domestic tungsten concentrates indicated that aluminothermic reduction with a wolframite to aluminum powder ratio of 2.85 to 1 gave the best yield of ferrotungsten.[10]

Korea, North.—While no official information was available on the North Korean tungsten industry, reserves are believed to total some 250 million pounds, tungsten content, and annual production is estimated to be 4.7 million pounds of contained tungsten. The average grade of this ore reportedly ranges from 1.0 to 1.5 percent WO_3 and the deposits are believed to be a continuation of some of the deposits in mainland China. North Korea is believed to consume from 60 to 80 percent of its domestic output in production of ferrotungsten for use in specialty steel manufacture.

Korea, South.—Korea Tungsten Mining Co., Ltd. (KTMC), continued the deep shaft sinking project initiated at the Sangdong mine in 1967. Ore reserves now total 16 million tons averaging 0.7 percent WO_3, 0.06 percent molybdenum disulfide, and 0.05 percent bismuth. Capacity of the gravity-flotation beneficiation plant was expanded from 1,200 to 1,800 tons per day. The Seoul Refinery of KTMC processed the concentrate and produced ferrotungsten, ferromolybdenum, bismuth subnitrate, and bismuth metal for export.

Poland.—It has been reported that Poland, which usually obtains much of its tungsten from mainland China, was able to obtain only about 20 percent of its needs at the recent Canton Fairs.

Portugal.—Following the 20-percent increase in production of tungsten concentrates achieved in the second quarter at the Panasqueira mine of Beralt Tin & Wolfram Ltd., the company announced that it would increase production again by a further 50 percent late in 1970. This would bring Portugal to an annual production level of about 2,000 tons.

Sweden.—A new research center for the evaluation of tungsten carbide products was recently opened at the Sandvik Steel Works' Coromant division in Stockholm. This new research center has been designed to serve as a pilot plant for the group's international development plans. Production of tungsten carbides by Sandvik exceeds 1,000 tons per year and is greater than all the rest of European production combined.

Fagersta Bruks a.-b. is investing $13 million in tungsten carbide development. About two-thirds of the money will be used on research, development, and manufacture of carbide products at a new plant at Fagesta. The remainder will be used to expand the firm's Seco factory at Arboga and to acquire Uddeholm's carbide production facilities at Stockholm.

The development of Sweden's advanced position in the field of tungsten carbide production was discussed.[11]

Turkey.—The Rasih ve Ihsan Madenclik Limited announced that it was seeking foreign assistance in drilling and evaluating the tungsten deposits at Akdag (Yozgat) and in the Nigde area. If the deposits prove to be commercial, a flotation and recovery mill will be constructed to process the ores.

U.S.S.R.—As in the previous year, the Soviet Union is believed to have continued to be a net importer of tungsten concentrate in 1968. While domestic production continued to come from large modern facilities in the northern Caucasus, reports from trading sources indicated that Chinese tungsten may have been imported through Czechoslovakia.

---

[9] DeKate, Y. G. Production of Tungsten Ore in India. The Eastern Metals Review (Calcutta, India), Annual Number, Feb. 5, 1968, pp. 35–37.

[10] Dutta, R. A., and J. Bhattacheryya. Ferrotungsten and Tungsten Powder From Indian Wolframite Concentrate. J. Mines, Metals & Fuels (Calcutta, India), v. 16, No. 10, October 1968, pp. 373–375.

[11] Rossander, Bror. New Swedish Developments in Tungsten Carbide Tipped Integral Drill Rods. World Mining, v. 4, No. 10, September 1968, pp. 56–57.

TECHNOLOGY

Interest in the extractive metallurgy and high-temperature applications of tungsten continued during the year. In one Bureau of Mines study, a solvent extraction procedure was developed to obtained concentrated samples for the determination of metallic trace elements in tungsten.[12] A two-phase molten halide-silicate technique was developed by the Bureau of Mines for recovering tungstic oxide (WO_3) from scheelite ($CaWO_4$) and wolframite [$(Fe,Mn) WO_4$] concentrate which indicated that the halide phase extracted over 99 percent of the WO_3 while the lower silicate phase retained about 90 percent of the calcium, iron, or mangenese oxide.[13]

Methods of converting $WOCl_4$ to pure WCl_6 suitable for conversion to tungsten metal were also investigated by the Bureau of Mines.[14] Conversions of more than 95 percent was achieved with the reagents chlorine, $COCl_2$, and CCl_4, at 800° C.

When a low degree of supersaturation was maintained, hydrogen reduction of tungsten, hexachloride (WCl_6) temperatures between 2,700° C and 3,300° C in vacuum yielded a small quantity of tungsten whiskers.[15] Direct measurements of 3 to 4 million psi (pounds per square inch) were obtained for the ultimate strength of individual tungsten whiskers averaging 3 to 4 microns in diameter. This compares with strengths of 300,000 to 400,000 psi for 13-micron-diameter commercial filaments.[16] Additional research on tungsten was published in the following reported release during the year.[17]

A technical progress review of tungsten alloy development, irradiation effects, methods of fabrication, oxidation and corrosion resistance, and coating studies of tungsten was conducted for the Atomic Energy Commission (AEC) with special emphasis on high-temperature reactor material applications.[18]

A considerable interest in methods of preparing dense coherent deposits of tungsten and tungsten alloys by vapor deposition was indicated by the number of various reports issued on the subject.[19]

A comprehensive review of solid lubricant technology was published which discussed the relative merits of tungsten disulfide (WS_2) and tungsten diselenide (WSe_2) as new solid film lubricants.[20]

The state of technology of tungsten-base refractory alloys was evaluated and physical and mechanical properties, liquid-metal corrosion resistance, high-temperature applications and technology, and alloy development programs were reviewed.[21]

---

[12] Green, Thomas E. Extraction of 8-hydroxy quinoline Complexes of Trace Elements From Tungsten Solutions. BuMines Rept. of Inv. 7072, February 1968, 17 pp.

[13] Gomes, John M., Kenji Uchida, and Don H. Baker, Jr. A High-Temperature, Two-Phase Extraction Technique for Tungsten Minerals. BuMines Rept. of Inv. 7106, April 1968, 13 pp.

[14] Henderson, A. W., D. H. Yee, and F. E. Block. Conversion of Tungsten Oxychloride to Tungsten Hexachloride. BuMines Rept. of Inv. 7152, 1968, 14 pp.

[15] Starliper, A. G., and H. Kenworthy. Tungsten Whiskers by Vapor-Phase Growth. BuMines Rept. of Inv. 7118, 1968, 13 pp.

[16] Starliper, A. G., and H. Kenworthy. Application for Filiform Tungsten To Reinforce Metals. BuMines Rept. of Inv. 7130, May 1968, 18 pp.

[17] Acherman, W. L., J. P. Carter, and David Schlain. Corrosion Properties of the TZM and Molybdenum-30 Tungsten Alloys. BuMines Rept. of Inv. 7169, August 1968, 23 pp.

Bureau of Mines. Bureau of Mines Research on the Analysis of High-Purity Tungsten. Inf. Cir. 8397, October 1968, 10 pp.

[18] Simons, E. M., S. W. Porembka., Jr., and D. L. Keller, Reactor Materials. Battelle Memorial Inst., Columbus, Ohio, v. 11, Nos. 1–4, 1968, 283 pp.

[19] Donaldson, J. G., F. W. Hoertel, and A. A. Cochran. Preliminary Study of Vapor Deposition of Rhenium and Rhenium-Tungsten. J. Less-Common Metals, Amsterdam, the Netherlands, v. 14, No. 1, January 1968, pp. 93–101.

Macklin, Buford A. Research on Vapor Plating From Organometallic Compounds. General Technologies Corp., Reston, Va., AFML–TR–68–9 (U.S. Air Force Contract No. AF 33 (615)–5324), February 1968, 66 pp.

Mehalchick, Emil J., and Martin B. MacInnis. Preparation of Vapor-Deposited Tungsten at Atomospheric Pressure. Electrochem. Technol., v. 6, Nos. 1–2, January–February 1968, pp. 66–69.

[20] Campbell, Mahlon E. Solid Lubrication Technology: A Review. Mech. Eng., v. 90, No. 2, February 1968, pp. 28–36.

[21] Machlin, Irving. Symposium on Metallurgy and Technology of Refractory Metal Alloys: A-State-of-the-Art Review. J. Metals, v. 20, No. 9, September 1968, pp. 21–25.

Machlin, Irving, R. T. Begley, and E. D. Weisert (eds.). Refractory Metal Alloys—Metallurgy and Technology. Plenum Press, New York, 1968, 491 pp.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/29

Uranium

By Richard F. Stevens, Jr.[1]

To meet the increasing demand for uranium in nuclear electric power stations the domestic uranium industry experienced a strong resurgence during 1968. This resurgence was evidenced by the significant increase in uranium exploration and development drilling which doubled that of 1967, attaining a record high of 23.8 million feet; a 22 percent increase in mine production; and a 35 percent rise in mill production. The most significant development in 1968 was in the quantity of processed uranium concentrate sold to private industry which increased by a factor of over seven to 5,000 tons uranium oxide (U_3O_8). A review and projection of nuclear generating capacity published by the Organization for Economic Co-Operation and Development (OECD) indicated that free world capacity could total 383,000 megawatts by the year 1985.

Legislation and Government Regulations.—Early in 1969 the U.S. Atomic Energy Commission (AEC) announced its intention to reduce the amount of U_3O_8 to be acquired through the "stretchout" procurement program which will expire on December 31, 1970, by not more than 4,000 tons of U_3O_8.[2] In addition, an announcement of the Commission's supply policies and related activities, including toll enrichment, was published.[3]

Late in the year the Labor Department issued revised allowable radiation standards for uranium mining which specified that exposure to radon-daughter products shall not exceed 2 working-level months (WLM) in any consecutive 3-month period and no more than 4 WLM in any consecutive 12-month period.[4] A working-level month was defined as the exposure received by a worker breathing air containing the equivalent of 100 picocuries of radon-222 per liter of air for 4⅓ weeks of 40 hours each.

Additional regulations were issued by the AEC and the Department of Transportation covering the shipment of radioactive materials and the requirements for semiannual reports of private inventories of radioactive material.[5]

Table 1.—Salient uranium statistics

(Short tons)

	1964	1965	1966	1967	1968
United States:					
Mine ore shipments	5,359,653	4,385,995	4,352,651	5,276,038	6,446,829
Concentrate (U_3O_8 content):					
AEC procurement	11,847	10,442	9,487	8,425	7,338
Private industry sales [e]	-----------	-----------	100	700	5,000
Imports: Concentrate (U_3O_8)	5,756	2,986	2,123	1,309	470
Free world: Production (U_3O_8)	[r] 26,204	[r] 20,589	[r] 19,520	18,978	[p] 22,344

[e] Estimate. [p] Preliminary. [r] Revised.

---

[1] Physical scientist, Division of Mineral Studies.

[2] U.S. Atomic Energy Commission. Uranium Procurement Contracts. 34 F.R. 645, Jan. 16, 1969.

[3] U.S. Atomic Energy Commission. Uranium: Supply Policies and Related Activities. 33 F.R. 12756, Aug. 16, 1968.

[4] U.S. Department of Labor. Part 50—Safety and Health Standards for Federal Supply Contracts: Radiation Standards for Mining. 33 F.R. 19947, Dec. 28, 1968.

[5] U.S. Atomic Energy Commission. Special Nuclear Material Status and Transfer Reports. 33 F.R. 9388, June 27, 1968.
U.S. Department of Transportation. Radioactive Materials and Other Miscellaneous Amendments, 33 F.R. 14918, Oct. 4, 1968.

In 1968 AEC approved agreements with Colorado and Idaho under which these States assume part of the regulatory authority for private use of atomic energy materials within their borders. This brought to 19 the total of States with which similar agreements exist. Others are Alabama, Arizona, Arkansas, California, Florida, Kansas, Kentucky, Louisiana, Mississippi, Nebraska, New Hampshire, New York, North Carolina, Oregon, Tennessee, Texas, and Washington. In addition, 24 States and Puerto Rico have passed enabling legislation which will provide for the assumption of this responsibility.

In 1968 the Congressional Joint Committee on Atomic Energy (JCAE) held and reported on public hearings in which the atomic energy program was reviewed.[6]

A study on competition in the nuclear power industry was prepared for the AEC and the Department of Justice to provide background and economic data on the nuclear industry for use in preparing industry guidelines and Government actions.[7] This comprehensive study reviewed the present state of nuclear technology, projected uranium requirements, and the economics involved in all phases of the uranium power supply system.

As a result of preliminary studies on separating palladium, rhodium, and technetium from fission waste products, the AEC requested expressions of interest from the domestic industry on recovering these materials from waste fission products generated in the Hanford (Wash.) reactors.[8] The Commission also requested expressions of interest regarding the private operation of the shutdown Redox chemical processing facility at Hanford.[9]

A complete list and brief review of all the AEC rules and regulations which became effective or which were proposed and published in the Federal Register during 1968 was reported in the Commission's annual report.[10]

The AEC issued a revised report on procedures for packaging, measuring, and transferring uranium hexafluoride as part of its continual review to bring these procedures in phase with developing agreements for the supply of uranium enriched with uranium–235.[11]

DOMESTIC PRODUCTION

Mine and Mill Production.—Approximately 320 mining operations in eight States produced almost 6.5 million tons of uranium ore during the year, 22 percent more than was produced by some 500 operations in 1967. New Mexico continued to lead in production and accounted for 51 percent of the total recoverable uranium, followed by Wyoming with 25 percent, Colorado with 11 percent, and Utah with 7 percent. Next in order were Texas, Arizona, South Dakota, and North Dakota.

Uranium ores were processed at 16 mills during the year and concentrate containing 7,338 tons of U_3O_8 was shipped to the AEC from 13 of these mills. This compared with 8,425 tons shipped from 16 mills in 1967.

Substantial quantities of uranium were processed for private industry during the year as slightly over 5,000 tons of U_3O_8 was sold in 1968 compared with an estimated 700 tons in 1967. Sales to private industry, which represented about 40 percent of mill production in 1968, will increase both in volume and relative percentage as uranium is processed for the rapidly growing nuclear-fueled electrical utilities and as the AEC terminates its uranium procurement program.

During the year, 12 companies operating 13 mills supplied uranium concentrate to the AEC under "stretchout" contracts. However, two of these companies, each

---

[6] Joint Committee on Atomic Energy. Atomic Energy Legislation Through 90th Congress, 2d Session, U.S. Government Printing Office, December 1968, 370 pp.

———. International Agreements for Cooperation—1967–68. U.S. Government Printing Office, 1969, 467 pp.

———. Licensing and Regulation of Nuclear Reactors. U.S. Government Printing Office, 1968, pt. 1, 448 pp.; pt. 2, 555 pp.

———. Participation by Small Electrical Utilities in Nuclear Power. U.S. Government Printing Office, 1968, pt. 1, 757 pp.; pt. 2, 624 pp.

[7] Arthur D. Little, Inc. Competition in the Nuclear Power Supply Industry (NYO–3853–1). U.S. Government Printing Office, December 1968, 430 pp.

[8] U.S. Atomic Energy Commission. Press Release L–252, Oct. 31, 1968, 2 pp.

[9] U.S. Atomic Energy Commission. Press Release L–238, Oct. 9, 1968, 2 pp.

[10] U.S. Atomic Energy Commission. Annual Report to Congress for 1968. January 1969, pp. 303–306.

[11] U.S. Atomic Energy Commission. Uranium Hexafluoride: Handling Procedures & Container Criteria. ORO–651, Revision 2, November 1968, 80 pp.

Table 2.—Uranium mine and mill production in 1968, by States

State	Ore shipped		Recoverable U_3O_8 content			Number of mills	Concentrate purchased by AEC	
	Short tons	Value (thousands)	Percent	Thousand pounds	Value (thousands)		U_3O_8 thousand pounds	Cost (thousands)
Arizona	44,171	$1,396	0.37	295	$1,923	------	------	-------
Colorado	654,917	11,472	.22	2,706	20,009	4	1,564	$12,514
New Mexico	3,166,498	47,352	.20	12,282	95,144	4	8,600	68,801
Utah	386,683	7,148	.23	1,712	13,175	1	1,323	10,582
Wyoming	1,836,389	21,471	.17	5,928	44,343	5	3,134	24,699
Other States [1]	358,171	4,657	.18	1,217	8,103	2	54	430
Total	6,446,829	93,496	.19	24,140	182,697	16	14,675	117,026

[1] Ore shipments: North Dakota, South Dakota, and Texas, Mills: South Dakota 1 and Texas 1. Concentrates: South Dakota and Texas.

Table 3.—Uranium ore-processing plants, December 31, 1968

State and company	Plant location	Tons U_3O_8 deliverable to AEC under contracts FY 1969–70
Colorado:		
American Metal Climax, Inc	Grand Junction	----------
Cotter Corp	Canon City	----------
Union Carbide Corp	Rifle	1,866
Do	Uravan	
New Mexico:		
The Anaconda Company	Bluewater	1,500
Foote Mineral Co.[1]	Shiprock	4
Kerr-McGee Corp	Grants	2,267
United Nuclear-Homestake Partners (formerly Homestake-Sapin Partners).	----do	[2] 3,333
South Dakota: Mines Development, Inc	Edgemont	14
Texas: Susquehanna-Western, Inc	Falls City	6
Utah: Atlas Corp.[3]	Moab	598
Wyoming:		
Federal-American Partners (formerly Federal-Radorock-Gas Hills Partners).	Gas Hills	350
Petrotomics Co.[3]	Shirley Basin	----------
Union Carbide Corp	Gas Hills	379
Utah Construction & Mining Co	----do	934
Western Nuclear, Inc	Jeffrey City	555
Total		11,806

[1] Foote discontinued operation of the Shiprock mill in July 1968, and the plant was placed on "stand-by"

[2] Includes 1,637 tons under contract to United Nuclear Corp., which is treated in the United Nuclear-Homestake Partners mill under a toll agreement.

[3] At yearend the mill was not operating because of a fire which closed the plant late in the year.

Source: U.S. Atomic Energy Commission, Division of Raw Materials.

operating a mill, processed material primarily for outside sales to private industry. These companies, Mines Development, Inc., and Susquehanna-Western Inc. have contracts to deliver a total of 20 tons of U_3O_8 to AEC in fiscal year (FY) 1969. With the completion of these contracts both companies will process uranium concentrate exclusively for outside sales.

Of the 16 mills which were in operation at the beginning of 1968, only 13 were in operation at yearend. In July the Shiprock, N. Mex., uranium-vanadium mill of the Foote Mineral Co. was shut down and placed on "standby" as a result of the decline in availability of high-grade ores and the increased costs of sulfuric acid and other raw materials. Two other mills, those operated by Petrotomics Co. and Atlas Corp., were closed late in the year by fires which destroyed the kerosine portions of the solvent extraction circuits. The Petrotomics mill will reportedly operate at a capacity of about 500 tons per day until repairs and expansion are completed.

In addition to the 16 mills which operated during 1968 private industry announced plans to further increase the capacity at three mills and to construct five additional uranium processing mills, as indicated:

Company	Location	Capacity, tons per day	Startup
MILL EXPANSION			
Kerr-McGee Corp	Ambrosia Lake, N. Mex	6,000	1968
Petrotomics Co	Shirley Basin, Wyo	1,500	1969
Susquehanna-Western, Inc	Falls City, Tex	600	1968
NEW MILLS			
Kerr-McGee Corp	South Powder River Basin, Wyo	1,000-3,000	1971
Rio Algom Mines, Ltd	Moab, Utah	600	1972-73
Susquehanna-Western, Inc	South-central Tex	1,000-2,000	1970
United Nuclear Corp	Gallup, N. Mex	2,000	1970
Utah Construction & Mining Co	Shirley Basin, Wyo	1,500	1970

Kerr-McGee Corp., the largest domestic uranium producer began developing its seventh underground uranium mine in the Ambrosia Lake area near Grants, N. Mex. Both this mine and the sixth, which was started in 1967, were expected to be completed in 1969 and to begin production in 1970. The development of an eighth mine is scheduled for 1969 and planning is underway for two additional mines.

The Canadian firm, Rio Algom Mines Ltd., Toronto, announced that it will supply 3 million pounds of U_3O_8 to the Duke Power Co. of Charlotte, N.C., over a 6-year period from its Humeca property near Moab, Utah, which is scheduled to begin production in early 1972.

Kerr-McGee is currently expanding the capacity of its Cimarron Uranium Fuels Plant by sixfold. This plant located north of Oklahoma City, Okla. converts uranium hexafluoride (UF_6) to uranium dioxide (UO_2) fuel pellets by the ammonium diuranate (ADU) process.[12]

Refining and Enrichment.—Production of enriched uranium continued at a reduced rate at all three of AEC's gaseous diffusion plants (Oak Ridge, Tenn., Paducah, Ky., and Portsmouth, Ohio) as the level of electrical power usage was further reduced to a total of 2,215 electrical megawatts (Mwe) at midyear. At Oak Ridge the power usage was reduced by 350 Mwe to 500 Mwe, at Paducah by 25 Mwe to 1,215 Mwe, and at Portsmouth by 200 Mwe to 500 Mwe. The "B" reactor at Hanford, Wash., the world's first plutonium production reactor, was shut down and placed on "standby" status on February 12, 1968, after 24 years of operation. On February 18, 1968, the 14 year old "L" plutonium production reactor at the Savannah River (S.C.) Plant was placed on "standby." Of the seven remaining production reactors which are continuing to produce weapons-grade plutonium, four (including the duel-purpose "N" reactor) are located at Hanford and three are at Savannah River. These production reactors also continued to produce significant quantities of nondefense plutonium, uranium-233, special isotopes, and radioisotopes. While the AEC has announced plans to shut down another production reactor at Hanford early in 1969, the Commission indicated that increased efficiency and productivity at the remaining six production reactors would be sufficient to provide all of the weapons-grade plutonium which will be required. The uranium hexafluoride (UF_6) plant at Paducah, Ky., placed on

---

[12] Kerr-McGee Corp. Annual Report 1968, 28 pp.
Prescott, James H. ADU Process Is Big Contender in Race To Meet Nuclear Power's Fuel Needs. Chem. Eng., v. 75, No. 10, May 6, 1968, pp. 146–148.

"standby" in 1964, was reactivated on August 1 to produce additional UF_6 feed for the three gaseous diffusion plants. This material will be used by the diffusion plants to supplement UF_6 normally received from toll enrichment customers. Because the enrichment stage of the uranium fuel processing cycle is the only area which remains completely under Government control, much discussion has been conducted on the possibility of turning this stage over to private ownership. The Commission released a report which included information, much of which had previously been classified, on the physical features, operating requirements, economics, potential improvements, and capabilities of each of the three enrichment plants.[13] Also included were estimated cost data for the construction of new gaseous diffusion enrichment plants.

During the year, Allied Chemical Corp., Metropolis, Ill., continued as the only commercial plant for converting uranium concentrate (U_3O_8) to UF_6, the feed material required in gaseous diffusion plants for the production of uranium enriched in Uranium-235. Although the plant was not operated in 1968, expansion continued and construction of the 10,000-ton-per-day facility is scheduled to be completed and begin startup by the end of 1969. Kerr-McGee began construction of the country's second privately owned UF_6 conversion plant east of Gore, Okla., during the year. This plant, designated the Sequoyah facility, will go onstream in 1970 with a capacity of 5,000 to 10,000 tons annually.

During the year Kerr-McGee signed the first domestic uranium toll enrichment contract with the AEC under which the AEC provides enrichment of privately owned UF_6 feed material. Under this agreement, a total of 114 tons of enriched uranium containing from 1.6 to 3.05 percent uranium-235 will be supplied between June 1, 1969, and December 1, 1973.

The AEC's feed materials plant at Fernald, Ohio, operated by the National Lead Co. of Ohio, continued to refine uranium concentrates and fabricate uranium fuel elements during the year.

Private industry also announced the construction and operation of facilities for the processing and storage of radioactive plutonium as follows:

Company	Location	Capacity, gallons	Startup
PLUTONIUM FUELS PROCESSING FACILITIES			
Kerr-McGee Corp.	Adjacent to company's Cimarron Uranium Fuels Processing Plant, Oklahoma	-----	1969
Westinghouse Electric Corp.	Cheswick, Pa.	-----	1968
PLUTONIUM STORAGE FACILITY			
Western Construction Corp.	West Valley, N.Y.	2,600	1969

Heavy Water.—Although heavy water production at the Commission's Savannah River Plant increased slightly over that of 1967, sales continued to exceed production and the difference was obtained from AEC stocks. Because projected requirements for the next several years exceed the available supply, sales will continue to be made on a "First-come, first-served," basis.

Several comprehensive reviews were published which evaluated the current and projected uranium supply-demand situation.[14]

CONSUMPTION AND USES

As opposed to previous years when essentially all uranium production went into the AEC stockpile, only 60 percent of 1968 mill production went to the AEC while the remainder was shipped to private industry.

---

[13] U.S. Atomic Energy Commission. AEC Gaseous Diffusion Plants Operations. Oak Ridge, Tenn., ORO-658, February 1968, 45 pp.

———. Press Release K-145, June 14, 1968, 3 pp.

[14] Carthew, Douglas. Uranium Update—Exploding Demand Sparks a Rush To Develop New Reserves. Eng. and Min. J., v. 169, No. 12, December 1968, 67–71.

The Chase Manhattan Bank, N.A. Outlook for Energy in the United States. New York, October 1968, 60 pp.

———. The Outlook for Uranium. New York, March 1969, 23 pp.

Electrical World. 14th Annual Nuclear Report. V. 171, No. 15, Apr. 14, 1969, pp. 77–89.

Federal Reserve Bank of Kansas City. Uranium: A New Commercial Energy Source. Monthly Review, Kansas City, Mo., April 1968, pp. 3–9.

Sherman, John T. Uranium-Annual Survey and Outlook. Eng. and Min. J., v. 170, No. 3, March 1969, pp. 104–108.

Westinghouse Electric Co. Nuclear Fuel. Pittsburgh, Pa., 1968, 47 pp.

Weapons and Explosive Applications.—Production of weapons-grade plutonium continued in the graphite-moderated reactors at Hanford and in the heavy water-moderated reactors at Savannah River at a slightly reduced rate. Only three underground nuclear-explosion tests were conducted under the Plowshare Program during the year. The preliminary results of Project Gasbuggy, the nuclear-explosion conducted in late 1967 and designed to stimulate the flow of natural gas in a tight rock formation were released.[15] A report on the geological effects of Project Gnome, another previous underground nuclear explosion in the Plowshare Program was issued.[16]

A review of the Plowshare Program was issued during the year following legislative hearings on the subject.[17]

Civilian Reactors.—The trend by electric utilities toward nuclear powerplant installations continued during the year, but at a decreased rate as plans were announced for the construction of only 13 nuclear power reactors, a 55-percent decrease from the high reported in 1967. Table 5 lists all the central-station nuclear powerplants which were in operation, under construction, or planned at yearend. Since these light-water reactor-types require from 0.6

---

[15] U.S. Atomic Energy Commission. Press Release L–111, May 31, 1968, 3 pp.
———. Press Release L–186, Aug. 8, 1968, 3 pp.
———. Press Release L–247, Oct. 23, 1968, 2 pp.

[16] Gard, Leonard M. Geological Studies, Project Gnome, Eddy County, New Mexico. U.S. Geol. Survey Prof. Paper 589, 1968, 33 pp.

[17] Joint Committee on Atomic Energy. Commercial Plowshare Services. U.S. Government Printing Office, 1968, 444 pp.

Table 4.—Underground nuclear detonations, 1968

Name	Date	Yield [1]
Plowshare (peaceful uses) series:		
Cabriolet	Jan. 26	2.5 kiloton
Buggy [2]	Mar. 12	5 kilotons.
Stoddard	Sept. 17	Low intermediate
Schooner	Dec. 8	35 kilotons.
Defense-related detonations:		
Crosstie series (January–June):		
Hupmobile	Jan. 18	Low.
Staccato	Jan. 19	Low intermediate.
Faultless [3]	Jan. 19	Intermediate.
Knox	Feb. 12	Low intermediate.
Dorsal Fin [4]	Feb. 29	Low.
Pommard	Mar. 14	Do.
Stinger [5]	Mar. 22	Low intermediate.
Milk Shake [4]	Mar. 25	Low.
Noor	Apr. 10	Low intermediate.
Shuffle	Apr. 18	Do.
Scroll [5] [6]	Apr. 23	Low.
Boxcar [5]	Apr. 26	Low megaton.
Clarksmobile	May 17	Low intermediate.
Tub	June 6	Low.
Rickey [5]	June 15	Low intermediate.
Chateaugay [5]	June 28	Do.
Bowline series (July-December):		
Tanya	July 30	Low.
Diana Moon [4]	Aug. 28	Low.
Sled [5]	Aug. 29	Low intermediate.
Noggin	Sept. 6	Do.
Knife A	Sept. 12	Low.
Hudson Seal [4]	Sept. 24	Low.
Knife C	Oct. 3	Low.
Crew	Nov. 4	Low intermediate.
Knife B	Nov. 15	Low.
Ming Vase	Nov. 20	Low.
Tinderbox	Nov. 22	Low.
Tyg	Dec. 12	Low.
Benham [5]	Dec. 19	Low megaton.

[1] Low yield, less than 20 kilotons low intermediate yield, 20 to 200 kt; intermediate yield, 200 kt to 1 megaton (mt); and low megaton yield, 1 to several mt. 1 kt is equivalent to 1,000 tons of TNT.

[2] In the Buggy experiment 5 nuclear explosives, each with a yield of 1 kt, were placed in a row and detonated simultaneously.

[3] Central Nevada calibration test at Hot Creek Valley, Nev., supplemental test area.

[4] Department of Defense (DOD) test conducted with AEC laboratory assistance.

[5] Conducted in the Pahute Mesa area of the Nevada Test Site (NTS).

[6] Joint AEC–DOD Velva detection experiment.

Source: U.S. Atomic Energy Commission. Annual Report to the Congress—1968. January 1969, pp. 192–202, 301.

to 0.9 ton U_3O_8 per Mw of electrical capacity (Mwe) for initial charge, the domestic demand for uranium can readily be estimated. After a few years of operation, additional uranium requirements of from 0.11 to 0.20 ton of U_3O_8 per Mw-year of operation will have to be considered.

An updated survey conducted by the AEC which reflected the fuel supply situation at the beginning of 1969 is indicated in table 6.[18] These increased commitments represent material primarily scheduled for delivery in 1972 or later.

Brief descriptions and highlights of some of the major reactors are listed below.[19]

1. Water reactors:

The Connecticut Yankee Atomic Power Plant started commercial operation on January 1, 1968, and produced over 3.5 billion kilowatt-hours during the year.

The 430-Mwe pressurized water San Onofre Nuclear Generating Station, San Clemente, Calif., was shutdown for 6 months during 1968 as a result of a fire in

Table 5.—Principal domestic civilian nuclear power reactors

Reactor	Location	Electrical capacity, megawatts (Mwe)	Initial criticality
OPERABLE			
Shippingport Atomic Power Station	Shippingport, Pa	90	1957
Dresden Nuclear Power Station, Unit 1	Morris, Ill	200	1959
Yankee Nuclear Power Station	Rowe, Mass	175	1960
Big Rock Point Nuclear Plant	Big Rock Point, Mich	70	1962
Elk River Reactor	Elk River, Minn	22	1962
Indian Point Station, Unit 1	Indian Point, N.Y	265	1962
Enrico Fermi Atomic Power Plant	Lagoona Beach, Mich	61	1963
Humbolt Bay Power Plant, Unit 3	Eureka, Calif	69	1963
Peach Bottom Atomic Power Station, Unit 1	Peach Bottom, Pa	40	1966
San Onofre Nuclear Generating Station	San Clemente, Calif	430	1967
LaCrosse Boiling Water Reactor	Genoa, Wis	50	1967
Connecticut Yankee Atomic Power Plant	Haddam Neck, Conn	462	1967
Total operable capacity		1,934	
UNDER CONSTRUCTION			
Oyster Creek Nuclear Power Plant, Unit 1	Toms River, N.J	515	1969
Nine Mile Point Nuclear Station	Seriba, N.Y	500	1969
Dresden Nuclear Power Stations, Units 2 and 3	Morris, Ill	1,430	1969
Robert Emmett Ginna Nuclear Power Station	Ontario, N.Y	420	1969
Millstone Nuclear Power Station, Unit 1	Waterford, Conn	652	1969
Indian Point Station, Unit 2	Indian Point, N.Y	873	1970
H.B. Robinson S.E. Plant, Unit 2	Hartsville, S.C	663	1970
Palisades Nuclear Power Station, Unit 1	South Haven, Mich	700	1970
Quad-Cities Station, Units 1 and 2	Cordova, Ill	1,430	1970–71
Browns Ferry Nuclear Power Plant, Units 1, 2, and 3	Decatur, Ala	3,194	1970–72
Turkey Point Station, Units 3 and 4	Turkey Point, Fla	1,303	1970–72
Monticello Nuclear Generating Plant	Monticello, Minn	472	1970
Peach Bottom Atomic Power Station, Units 2 and 3	Peach Bottom, Pa	2,130	1970–72
Point Beach Nuclear Plant, Units 1 and 2	Two Creeks, Wis	909	1970–71
Surry Power Station, Units 1 and 2	Gravel Neck, Va	1,566	1970–71
Oconee Nuclear Station, Units 1, 2 and 3	Seneca, S.C	2,523	1970–73
Vermont Yankee Generating Station	Vernon, Vt	514	1971
Three Mile Island Station	Goldsboro, Ill	813	1971
Diablo Canyon Nuclear Power Plant	Diablo Canyon, Calif	813	1971
Fort Calhoun Station, Unit 1	Fort Calhoun, Nebr	457	1971
Pilgrim Station	Plymouth, Mass	625	1971
Salem Nuclear Generating Station, Units 1 and 2	Salem, N.J	2,100	1971–72
Fort St. Vrain Nuclear Generating Station	Platteville, Colo	330	1971
Cooper Nuclear Station	Brownville, Nebr	778	
Prairie Island Nuclear Generating Plant, Units 1 and 2.	Red Wing, Minn	1,060	1972–74
Maine Yankee Atomic Power Plant	Wiscasset, Maine	790	1972
Kewaunee Nuclear Power Plant	Carlton, Wis	527	1972
Crystal River Plant, Unit 3	Red Level, Fla	825	1972
Zion Station, Units 1 and 2	Zion, Ill	2,100	1972–73
Rancho Seco Nuclear Generating Station, Unit 1	Clay Station, Calif	800	1973
Total under construction		31,812	

See footnotes at end of table.

---

[18] U.S. Atomic Energy Commission. Press Release M–118, May 20, 1969, 12 pp.

[19] Pages 84–96 of work cited in footnote 10.

Table 5.—Principal domestic civilian nuclear power reactors—Continued

Reactor	Location	Electrical capacity megawatts (Mwe)	Initial criticality
PLANNED			
Indian Point Station, Unit 3	Indian Point, N.Y	965	1972
Calvert Cliffs Nuclear Power Plant, Units 1 and 2	Lusby, Md	1,600	1972–73
Donald C. Cook Plant, Units 1 and 2	Bridgman, Mich	2,114	1972–73
Brunswick Steam Electric Plant, Units 1 and 2	Southport, N.C	1,642	1972–73
Oyster Creek Nuclear Plant, Unit 2	Toms River, N.J	815	1972
Malibu Nuclear Plant, Unit 1	Corral Canyon, Calif	462	1973
Bailly Generating Station	Dunes, Acres, Ind	515	1973
Bell Station	Lansing, N.Y	838	1973
Beaver Valley Power Station, Unit 1	Shippingport, Pa	783	1973
Edwin I. Hatch Nuclear Plant, Unit 1	Baxley, Ga	786	1973
Consolidated Edison Co., and Orange & Rockland Utilities, Inc.	New York	1,115	1973
Hutchinson Island, Unit 1	Fort Pierce, Fla	800	1973
Sequoyah Nuclear Power Plant, Units 1 and 2	Daisy, Tenn	2,248	1973–74
Duane Arnold Energy Center, Unit 1	Palo, Iowa	545	1973
James A. FitzPatrick Nuclear Power Plant	Scriba, N.Y	815	1973
Millstone Nuclear Power Station, Unit 2	Waterford, Conn	828	1973
North Anna Power Station, Unit 1	Louisa County, Va	800	1974
Trojan Station	Rainier, Oreg	1,105	1974
Seabrook Nuclear Station	Seabrook, N.H	860	1974
Davis-Besse Nuclear Power Station	Oak Harbor, Ohio	800	1974
Diablo Canyon Nuclear Power Station, Unit 2	Diablo Canyon, Calif	1,070	1974
Enrico Fermi Atomic Power Plant, Unit 2	Lagoona Beach, Mich	1,100	1974
Shoreham Nuclear Power Station	Brookhaven, N.Y	800	1975
Carolina Power & Light Co	North Carolina	821	
Philadelphia Electric Co., Units 1 and 2	Not determined	2,130	1975–77
Philadelphia Power & Light Co., Units 1 and 2	do	2,104	1975–77
Total planned		28,461	
Grand total		62,207	

Source: Adapted from "Nuclear Reactors Built, Being Built, or Planned in the United States as of Dec. 31, 1968," AEC Division of Technical Information, TID–8200 (19th Rev.) pp. 7–9.

the 480-volt switch gear room. Following the completion of repairs, the plant attained criticality and resumed operation in September.

The Elk River (Minn.) Reactor, which had operated throughout 1967, was shut down in February 1968 because of leakage from the primary reactor system. Although the leak source was located and repair was initiated, the plant remained shut down at yearend.

The LaCrosse Boiling Water Reactors, Genoa, Wis., was shutdown in mid-1968 because of equipment malfunctions during test operations. The reactor, which achieved criticality in July 1967, remained out of service until the latter part of 1968, while equipment repairs and modifications were made. Late in the year, power testing was resumed with completion scheduled for early 1969.

The Advanced Test Reactor (ATR), at the National Reactor Testing Station (NRTS), Idaho, was tested to determine ATR's design conditions of 250 thermal megawatts (Mwt). Full power tests are scheduled for 1969. The ATR is to be used for testing fuels and materials in a high neutron intensity environment (up to 2.5×10^{15} neutrons per square centimeter per second) and has nine independently adjustable testing zones for selecting a specific irradiation level for the materials to be tested.

2. Gas-cooled reactors:

The 40-Mwe Peach Bottom prototype high-temperature, gas-cooled reactor in Pennsylvania operated at essentially full power during periods of the greatest electrical demand. The reactor was shutdown from mid-January to May as required by AEC for examination at the end of 150 equivalent full power days of operation. From May through late October the reactor operated at a plant factor of about 82 percent. However, the fission product level in the helium coolant rose to a level of 34 curies. Although well below the allowable radiation level, this activity indicated that at least one fuel element had failed. On October 23, following an additional 150 equivalent full power days of operation, the reactor was again shutdown for inspection and maintenance as required under the AEC operating license. Examination showed that 11 of the 804 elements were broken and releasing activity to the coolant. At yearend removal of the broken fuel elements was still underway, but resumption of operations was scheduled for early 1969.

Construction of the Fort St. Vrain Nuclear Generating Station near Platteville, Colo., began during the year. This 330-Mwe reactor was designed on the basis of the Peach Bottom prototype. When it becomes operational in 1972, this reactor system will be fueled with 33,000 pounds of thorium and 1,650 pounds of enriched uranium.

The Ultra-High Temperature Reactor Experiment (UHTREX), Los Alamos, N. Mex., underwent a comprehensive series of reactor physics and equipment tests aimed at an approach to full power and operating temperature during the year. UHTREX is a 3-Mwe helium gas-cooled, graphite-moderated reactor which will be used to irradiate the types of fuel proposed for use in the High Temperature Gas-Cooled Reactor Program. Since some fission products are expected to be released from the fuel and contained in the UHTREX system, information will be obtained on the transport and deposition of fission products within the system and on problems of system maintenance. The circulating helium is continuously purified and fission products are removed and stored. This system does not need to be shutdown for refueling; the loading face can be rotated to allow fuel to be added to the core while the reactor is in operation.

3. Breeder reactors:

The Experimental Breeder Reactor No. 2 (EBR–2), NRTS, Idaho, continued to be used as a fast flux test facility for irradiating fuels and materials in the Liquid Metal Fast Breeder Reactor (LMFBR) Program. Operating power of the EBR–2 was increased from 45 to 50 Mwt and significant improvement in plant-use time was achieved during the year.

The Fast Flux Test Facility (FFTF) reactor, Richland, Wash., with a designed power level of 400-Mwt, is scheduled to become operational in 1974. The FFTF will become the Commission's major fuels and materials test irradiation facility in the LMFBR program and will have a fast flux more than double that of any other such facility. This system will be gas-cooled.

The Enrico Fermi Atomic Power Plant, Lagoona Beach, Mich., the Nation's first privately owned fast neutron breeder reactor, remained shutdown during the year following a partial fuel meltdown. Plans were made to begin loading the reactor with new fuel by May 1969.

On October 2, 1968, the Molten Salt Reactor Experiment (MSRE), Oak Ridge, Tenn., became the world's first reactor to operate on a loading of the manmade fuel uranium-233 which was obtained by irradiation of thorium-232. The MSRE is scheduled to operate with 75 pounds of uranium-233 fuel at a power level of 8 Mwt to evaluate the practicability of molten salt reactors having circulating fluid fuel with a breeding potential, and to evaluate the use of thorium-uranium fuels to determine the technology and economics of converting thorium to uranium-233. In addition, a conceptual design study of a 1,000-Mwe molten salt breeder reactor powerplant and the required fuel reprocessing facilities are being conducted.

The Commission continued to investigate gas-cooled fast reactors and is supporting work on the joint East Central Nuclear Group-Gulf General Atomic 1,000-Mwe GCFR concept in which plant design is being conducted to provide studies on alternate coolants for fast breeder reactors.

The AEC's Liquid Metal Fast Breeder Reactor (LMFBR) program continued during the year as the Program Office at Argonne National Laboratory, Argonne, Ill., prepared reports describing the LMFBR program plan.[20] The LMFBR program has been given the highest priority by the AEC because of the increased efficiency and fuel burnup achieved in this system. In conventional nuclear power reactors less than 1 percent of the fuel is utilized while in the LMFBR system about 70 percent of the fuel would be used in the conversion of uranium to fissionable plutonium. As the AEC did under its former (light water) Power Reactor Demonstration Program the Commission will initiate a LMFBR Demonstration Program in which AEC and industry will share the costs incurred in the construction and operation of fast reactors.

---

[20] U.S. Atomic Energy Commission. Liquid Metal Fast Breeder Reactor Program Plan. V. 1, Overall Plan, WASH–1101, November 1968, 240 pp.; v. 2, Plant Design, WASH–1102, December 1968, 197 pp.; v. 3, Components, WASH–1103, December 1968, 437 pp.; v. 4, Instrumentation and Control, WASH–1104, November 1968, 351 pp.; v. 5, Sodium Technology, WASH–1105, November 1968, 362 pp.; v. 6, Core Design, WASH–1106, November 1968, 333 pp.; v. 7, Fuels and Materials, WASH–1107, November 1968, 457 pp.; v. 8, Fuel Recycle, WASH–1108, November 1968, 235 pp.; v. 9, Physics, WASH–1109, December 1968, 294 pp.; v. 10, Safety, WASH–1110, December 1968, 256 pp.

Dual Purpose Reactors.—In addition to the graphite-moderated "N" Reactor at Hanford which produced both weapons-grade plutonium and steam for electrical generation during the year, two additional dual-purpose reactors are planned at Midland, Mich.

Reactor	Power (Mwe)	Start-up
Midland Nuclear Power Plant:		
Unit 1	530	1973
Unit 2	800	1974

Military Reactors.—Of 107 nuclear-powered submarines authorized by Congress, 80, including all 41 Polaris missile-launching types were in operation at yearend. In addition, 25 were under construction and two were planned. The aircraft carrier *Enterprise,* (eight reactors), the guided-missile cruiser *Long Beach* (two reactors), and the guided-missile frigates *Bainbridge* and *Truxton* (two reactors each) continued to operate without failure of the reactor plants during the year. The Navy's next attack aircraft carrier, the *Nimitz* (two reactors), is currently under construction and when completed, will be able to operate for 13 years without refueling its reactors, which will have the highest power of any in the naval reactor program. An additional two guided-missile frigates (two reactors each) and a special submarine, the Deep Submergence Research Vehicle, are under construction. A Congressional review of the current status of U.S. nuclear submarines was held during the year.[21]

Four nuclear reactors are currently in use by the Department of Defense primarily to supply electricity to remote locations.

Reactor	Location
Stationary Medium Power Plant No. (SM-1).	Fort Belvoir, Va.
Portable Medium Power Plant No. 3A (PM-3A).	McMurdo Sound, Antarctica.
Stationary Medium Power Plant No. 1A (SM-1A).	Fort Greely, Alaska.
STURGIS Floating Nuclear Power Plant (MH-1A).	Gutan Lake, Canal Zone.

In addition, seven nuclear reactors are currently in use as propulsion experiment and prototype reactors to supply information on the operating characteristics of reactor powered vessels.

Reactor	Location
S1W Reactor Facility	NRTS, Idaho.
Large Ship Reactor Prototype—(2 reactors)—(AIW)	Do.
Submarine Advanced Reactor Prototype (S3G)	West Milton, N.Y.
Small Submarine Reactor Prototype (S1C).	Windsor, Conn.
Destroyer Reactor Prototype (D1G).	West Milton, N.Y.
National Circulation Test Plant (S5G).	NRTS, Idaho.

Reactors for Export.—U.S. firms had contracts for 11 other reactors being built throughout the world and for two planned reactors. Locations are at Tarapur, India (380 Mwe); Tsuruga, Japan (310 Mwe); Niu, Japan (341 and 500 Mwe); Fatuba, Japan (440 and 784 Mwe); Benznau, Switzerland (350 and 350 Mwe); Zorita, Spain (450 Mwe); Bilbao, Spain (440 Mwe); and Bern, Switzerland (306 Mwe). The planned reactors are located at Ringhals, Sweden (809 Mwe), and at Lonnae, South Korea (500 Mwe). The reactors under construction are scheduled for startup between 1969 and 1973.

A total of 55 test, research, and teaching reactors built in the United States were in operation throughout the free world at yearend, two others were being built, and two are planned.

Radioisotopes.—While the AEC continued to be principal domestic producer and distributor of radioisotopes, in 1968 it withdrew from the routine production and sales of cobalt-60 sources having a specific activity of 45 curies per gram or less as this material became available from commercial suppliers. Since 1961 the AEC discontinued the production and sales of 38 radioisotopes. As industry assumed increasing responsibility for routine production of many radioisotopes, research work at AEC radioisotopes production sites has been concentrated on the development of methods for producing new isotope preparations having research importance.[22] During the year phosphorus-33 and enriched krypton-85 were made available for industrial research. Polonium-210, curium-244, plutonium-238, promethium-147, cobalt-60, and thulium-170 were evaluated in radioisotope fuel development studies during the year.

---

[21] Joint Committee on Atomic Energy. Nuclear Submarines of Advanced Design, Part 2. U.S. Government Printing Office, 1968, 235 pp.

[22] U.S. Atomic Energy Commission. Research and Development Projects: 1968, Division of Isotopes Development. TID-24823, January 1969, 343 pp.

Table 6.—Projected commercial uranium requirements and sales[1]

(Tons of U_3O_8)

Year of delivery	Domestic sales and commitments: Annual	Domestic sales and commitments: Cumulative	Projected domestic requirements[2] (cumulative)
Pre–1969	5,700	5,700	7,800
1969	4,600	10,300	13,400
1970	8,100	18,400	20,900
1971	10,100	28,500	30,100
1972	12,200	40,700	42,600
1973	10,000	50,700	57,000
1974	7,900	58,600	72,000
1975	5,500	64,100	[e] 92,000
1976	2,200	66,300	[e] 110,000
1977	1,600	67,900	[e] 130,000
1978–82	3,400	71,300	[e] 265,000

[e] Estimate.

[1] In addition to these domestic commitments, 3,600 tons of U_3O_8 was contracted for future delivery to foreign users by domestic producers.

[2] Requirements each year include initial fuel for new reactors and makeup fuel for operating reactors, the latter vary from about 15 percent of total annual requirements in 1969 to about 60 percent in 1980. Fuel processing times are assumed and reactor characteristics supplied by reactor manufacturers are used. The tails assay in the uranium enrichment plants is taken as 0.2 percent U^{235}. Plutonium recycle in thermal reactors is assumed to start in 1974, reducing annual U_3O_8 requirements by about 2 percent in 1973 to 12 percent in 1980.

Because systems using radioisotopes as sources of heat or radiation are becoming increasingly important in the field of national defense, space, communications, health, navigation, weather prediction, food sterilization, process radiation, and oceanographic research, a report on the production and large-scale uses of radioisotopes was issued.[23]

Legislative hearings were held on the food irradiation program and were published in a comprehensive document which thoroughly reviewed and evaluated this program.[24]

---

[23] U.S. Atomic Energy Commission. Radioisotopes—Production and Development of Large-Scale Uses. WASH Rept. 1095, May 1968, 41 pp.

[24] Joint Committee on Atomic Energy. Hearings on Status of the Food Irradiation Program. U.S. Government Printing Office, 1968, 739 pp.

Table 7.—Heavy water (D_2O) activity

(Short tons)

	196	1965	1966	1967	1968
Domestic production	NA	NA	186	207	206
Domestic sales	3	4	7.3	6	8
Domestic leases	--	----	38.4	62	---
Foreign shipments (sales)	63	27.4	232	334	245
Foreign leases	--	186	94	14.5	---

NA Not available.
Source: AEC Annual Reports to Congress.

Table 8.—Enriched uranium furnished to industry, excluding the weapons production chain

(Pounds, uranium)

	Fiscal year 1964	1965	1966	1967	1968
Furnished as UF_6	256,620	336,835	628,701	373,963	852,240
Furnished in forms other than UF_6	4,490	3,180	11	211	139
Total	261,110	340,015	628,712	374,174	852,379

Source: U.S. Atomic Energy Commission. The Nuclear Industry 1968. Nov. 14, 1968, p. 59.

Table 9.—Principal producers and fabricators of nuclear fuels

Company and principal location	Producer of uranium fuels: Metals, oxides or compounds	Producer of uranium fuels: Coated particles	Fabricators of uranium fuels: Oxides	Fabricators of uranium fuels: Metals	Plutonium capability
Aerojet-General Nucleonics, San Ramon, Calif	-------	-------	-------	X	X
Atomics International, Canoga Park, Calif	-------	-------	X	X	X
The Babcock & Wilcox Co., Lynchburg, Va	-------	-------	X	-------	-------
Combustion Engineering, Inc., Windsor, Conn	-------	-------	X	-------	-------
General Electric Co., San Jose, Calif	X	-------	-------	X	X
Gulf General Atomic, Inc., San Diego, Calif	-------	X	X	-------	-------
Kerr-McGee Corp., Oklahoma City, Okla	X	-------	-------	-------	-------
M&C Nuclear, Inc., Attleboro, Mass	X	-------	-------	X	-------
National Lead Co., Albany, N.Y	X	-------	-------	X	-------
Nuclear Fuel Services, Erwin, Tenn	X	X	X	-------	X
Nuclear Materials & Equipment Corp., Apollo, Pa	X	X	X	X	X
Nuclear Metals Division, Whittaker Corp., West Concord, Mass	-------	-------	-------	X	-------
United Nuclear Corp., Hematite, Mo., and New Haven, Conn	X	X	X	X	X
Westinghouse Electric Corp., Cheswick, Pa	-------	-------	X	-------	X

Source: U.S. Atomic Energy Commission. The Nuclear Industry, 1968. Nov. 14, 1968, pp. 55–57, 60.

Table 10.—Principal suppliers of radioisotopes, radiochemicals, and radiopharmaceuticals during 1968

Name	Radioisotopes	Radiochemicals	Radio pharmaceuticals
Abbott Laboratories, North Chicago, Ill	X	-------	X
Atomic Corporation of America, Sun Valley, Calif	-------	X	-------
Babcock & Wilcox, Lynchburg, Va	X	-------	-------
Bio-Nuclear Division of Bio-Assay Labs, Houston, Texas	-------	X	-------
Bio-Rad Laboratories, Richmond, Calif	-------	X	-------
Calbiochem, Los Angles, Calif	-------	X	-------
Cambridge Nuclear Corp., Cambridge, Mass	X	X	X
General Electric Co., Pleasanton, Calif	X	X	-------
General Nuclear, Inc., Houston, Texas	-------	X	-------
Hastings Radiochemical Works, Houston, Texas	X	X	X
International Chemical & Nuclear Corp. Burbank, Calif., INC Division, City of Industry, Calif. (includes Volk Radio-chemical)	X	X	-------
Nuclear Science Division, Pittsburgh, Pa	-------	X	-------
U.S. Nuclear Corp. Burbank, Calif	-------	X	-------
Isotope Products Lab., Los Angeles, Calif	X	-------	-------
Isotopes, Inc., Westwood, N.J., and Baltimore, Md. (a Teledyne company)	-------	X	-------
Neutron Products, Inc., Dickerson, Md	X	-------	-------
New England Nuclear Corp., Boston, Mass	X	X	X
Nuclear-Chicago Corp. Des Plaines, Ill. (G.D. Searle Co.)	-------	X	-------
Nuclear Consultants Corp., a Division of Mallinckrodt Chemical Works, St. Louis, Mo	X	X	X
Nuclear Equipment Chemical Corp., Farmingdale, N.Y	-------	X	X
Schwartz Bio-Research Inc., a subsidiary of Becton, Dickinson & Co., Orangeburg, N.J	-------	X	-----
E.R. Squibb & Sons, New Brunswick, N.J	-------	-------	X
Tracerlab, a Division of L.F.E. Inc., Waltham, Mass	-------	X	-------
Union Carbide Corp., Tuxedo, N.Y	X	X	X

Source: U.S. Atomic Energy Commission. The Nuclear Industry, 1968. Nov. 14, 1968, pp. 142–143, 147.

Table 11.—Irradiated nuclear fuel reprocessing facilities

Name	Location	Operator	Capacity	Status
GOVERNMENT (AEC) OWNED				
Fuel Cycle Facility	National Reactor Testing Station (NRTS), Idaho	Argonne National Laboratory.	6–11 pounds per day	Operational.
Idaho Chemical Processing Plant	NRTS, Idaho	Idaho Nuclear Corp	1,750 pounds per day [1]	Do.
Purex Plant	Hanford, Wash	Atlantic Richfield Hanford Co. (ARHCO).	NA	Do.
Redox Plant	Hanford, Wash	Isochem, Inc	1–2 tons per day [e]	Shut down—end of 1966 and placed on "standby".
Savannah River Separation Facilities (2 plants)	Savannah River, South Carolina.	E.I. duPont de Nemours & Co., Inc.	NA	Both plants are in operation.
Transuranium Processing Plant	Oak Ridge, Tenn	Union Carbide Corp	(2)	In operation—dedicated November 1966.
PRIVATELY OWNED				
ARCO	Near Leeds, S.C	Atlantic Richfield Co. (ARCO).	1,500 metric tons of uranium (MTU) per year.	Tentatively scheduled to go on stream in 1974.
Unnamed [3]	West coast	do		Scheduled to go on stream in late 1970.
Barnwell Nuclear Fuel Plant	On the AEC's Savannah River Plant, South Carolina.	Allied Chemical Corp	5 MTU per day	Scheduled to go on stream in 1973.
Midwest Fuel Recovery Plant	Morris, Ill	General Electric Co	300 MTU per year	Scheduled to go on stream in 1970.
NFS plant	West Valley, N.Y	Nuclear Fuel Services	300 tons per year	In operation since April 1966.
Unnamed		National Lead Co. [4]		
Do		Gulf General Atomic Inc. [4]		

[e] Estimate. NA Not available.

[1] Processing rate of mixed aluminum—and zirconium-based fuels. Exact capacity depends upon type and quantity of fuel processed. The capability to process certain stainless steel type fuels has been developed and is being installed.

[2] Designed to process and recover at least 1 gram of californium-252 (Cf^{252}) per year.

[3] ARCO continued to develop preliminary plans for a West Coast reprocessing facility.

[4] Both National Lead and Gulf General Atomic continued studies to evaluate the economic feasibility of entering the fuel reprocessing market.

PRICES AND SPECIFICATIONS

Ore and Concentrate.—Uranium processing mills controlled about 90 percent of ore reserves and production. All ore purchased from small independently owned mines was under individually negotiated contracts. While ore prices were not disclosed, most mines claimed to adhere to prices similar to those of AEC Circular 5, which expired in 1962, that ranged from $1.50 per pound of contained U_3O_8 on ore grade of 0.10 to about $3.50 per pound on ore containing 0.20 percent U_3O_8 or more.

Throughout the year the AEC contract price for specification grade concentrates was $8 per pound of U_3O_8. The actual average price paid by AEC during the year was $7.97 per pound of U_3O_8. During 1969 and 1970, AEC will pay $1.60 per pound of U_3O_8, plus 85 percent of the allowable production costs during the prior 6 years, subject to a maximum of $6.70 per pound. The average AEC contract price for all U_3O_8 delivered in 1969 and 1970 is expected to be between $5.50 and $6 per pound.

Prices for U_3O_8 sales made under private contract are not available but for 1968 was believed to be in the range of $5 to $5.50 per pound. In its reply to the AEC questionnaire, the private industry indicated that the average price was expected to rise from about $7.20 per pound of U_3O_8 in 1971 to about $8 per pound in 1974.[25]

Refined Uranium.—Normal uranium metal continued to be quoted periodically in American Metal Market at $18 to $24 per pound. Depleted uranium, in the form of UF_6 (67.6 percent uranium), was quoted at $2.50 per kilogram ($1.14 per pound) of contained uranium.

Special Nuclear Materials.—Base charges by AEC for enriched uranium varied with degree of enrichment and were $4.77, $8.48, and $9.59 per gram of U^{235} content for 1.0, 2.0, and 5.0 percent U^{235} enrichment, respectively. The cost of nuclear reprocessing charged by the AEC was $26 per kilogram unit of separative work (a measure of work done, not weight).

Heavy Water.—In midyear the AEC sales price of heavy water was increased $4 to $28.50 per pound to cover the higher operating costs of maintenance, higher wage rates, and rising steam power costs.

Plutonium.—The base price for plutonium (Pu) containing 6 to 12 percent of the isotope Pu^{240} is $43 per gram.[26] The base changes for other enriched plutonium, as reported in the Federal Register, are indicated below.

Percent Pu^{240} in plutonium	*Prices per gram*
3	$60
6	48
8	43
12	42
25	60
30	70

FOREIGN TRADE

As in 1967, no uranium ores and concentrates were exported during the year. Exports of uranium and thorium and their alloys, wrought or unwrought, increased by a factor of 12 and totaled 6,235 pounds, gross weight, valued at $125,686. Most of this material was shipped to Japan (85 percent), Spain (8 percent), and Canada (5 percent). The remainder was exported to Sweden, the Netherlands, Belgium-Luxembourg, West Germany, and Israel. Exports of uranium and thorium compounds more than doubled during the year and totaled 113,283, pounds, gross weight, valued at $322,062. This material was exported primarily to Indonesia (29 percent), West Germany (24 percent), the United Kingdom (17 percent), Hong Kong (12 percent), Japan (6 percent), and Canada (4 percent).

In 1968 exports of special nuclear materials (primarily enriched uranium, plutonium, and U^{233}) decreased 35 percent to $28 million and were shipped to the countries shown in table 13. The major ship-

---

[25] Work cited in footnote 18.

[26] U.S. Atomic Energy Commission. Plutonium and Uranium Enriched in U^{233}: Changes. 33 F.R. 15353, Oct. 16, 1968.

Table 12.—Exports of AEC produced nuclear materials, by countries, in calendar year 1968

(Pounds)

Country [1]	Enriched Uranium				Uranium-233	Plutonium (Pu)	Heavy water (D_2O)
	Less than 20% U^{235}		Greater than 20% U^{235}				
	Total U	U^{235}	Total U	U^{235}			
Argentina	-------	-------	27	24	-------	-------	-------
Austria	2	(2)	-------	-------	-------	-------	-------
Brazil	-------	-------	15	15	-------	-------	-------
Canada	5,051	174	266	246	-------	-------	97,557
Denmark	-------	-------	-------	-------	-------	-------	499
European Atomic Energy Community							
Belgium (Euratom):	484	20	-------	-------	(2)	(2)	-------
France	12,089	491	433	403	-------	66	-------
Italy	27,883	1,118	73	55	8	-------	878
Netherlands	-------	-------	2	(2)	-------	(2)	-------
West Germany	7,220	356	865	774	-------	32	24,451
International Atomic Energy Agency (IAEA):							
Austria	-------	-------	-------	-------	-------	(2)	-------
Congo (Kinshasa)	2	(2)	-------	-------	-------	-------	-------
Finland	4	(2)	-------	-------	-------	-------	-------
India	-------	-------	-------	-------	-------	(2)	-------
Mexico	38	7	-------	-------	-------	(2)	-------
Yugoslavia	2	(2)	-------	-------	-------	-------	-------
Israel	-------	-------	7	7	-------	-------	878
Italy	389	15	-------	-------	(2)	5	-------
Japan	4,965	561	108	95	-------	7	3,484
Korea, South	(2)	(2)	-------	-------	-------	-------	-------
South Africa, Republic of	-------	-------	-------	-------	-------	-------	125
Spain	1,014	40	-------	-------	-------	-------	-------
Sweden	-------	-------	-------	-------	-------	-------	362,274
Switzerland	72,094	1,995	-------	-------	-------	-------	375
Taiwan	-------	-------	4	4	-------	-------	-------
United Kingdom	17,910	253	141	132	-------	(2)	250
Total	149,147	5,030	1,941	1,755	8	110	490,771

[1] Represents country of initial destination. May not be country of final destination.
[2] Less than ½ unit.

Source: Division of International Affairs, U.S. Atomic Energy Commission.

Table 13.—U.S. exports of special nuclear material,[1] by countries

(Thousand dollars)

Country	1964	1965	1966	1967	1968
Argentina	$80	$82	$87	--------	$120
Australia	122	169	61	--------	--------
Belgium-Luxembourg	1,242	8,831	2,729	$236	--------
Canada	1,240	258	1,827	349	317
France	2,456	4,699	4,945	7,102	3,521
Germany, West	536	16,734	23,505	24,524	8,103
India	--------	--------	--------	7,264	2
Italy	8,411	574	5,727	175	4,463
Japan	195	400	212	1,314	3,038
Netherlands	1	272	--------	16	--------
Norway	506	21	--------	--------	--------
Sweden	390	236	58	71	332
Switzerland	--------	--------	26	--------	8,188
Spain	61	--------	49	2,956	--------
United Kingdom	27	3,144	2,668	6	343
Other	72	139	12	2	1
Total	15,339	35,559	41,906	44,015	28,428

[1] Includes plutonium, uranium-233, uranium-235, and uranium enriched in istopes U^{233} and U^{235}

Table 14.—U.S. exports of radioactive isotopes, compounds, and elements n.e.c., by major countries[1]

(Thousand curies and thousand dollars)

Country	1967		1968	
	Quantity	Value	Quantity	Value
Australia	11,419	$97	33,084	$119
Argentina	6,315	17	15,950	61
Belgium-Luxembourg	14,115	293	20,667	236
Brazil	359	19	14,603	24
Canada	2,948,562	538	314,099	743
Ceylon	------	------	302	45
Chile	884	17	3,786	16
Colombia	1,303	17	4,077	21
Egypt	52	1	10,420	21
France	10,025,910	157	548,534	330
Germany, West	124,613	394	123,151	499
Iceland	------	------	192,000	4
Indonesia	417	7	20,092	15
Israel	3,696	95	12,488	40
Italy	6,360	42	10,713	52
Japan	7,699	390	129,407	497
Mexico	1,262	38	12,989	124
Netherlands	4,116	53	16,704	33
New Zealand	1,032	17	2,307	11
Nicaragua	111	1	1,097	22
Nigeria	51	16	534,678	27
Peru	691	14	5,589	12
Saudi Arabia	100,475	22	------	------
South Africa, Republic of	2,662	35	13,953	22
Spain	1,260	46	14,202	54
Sweden	2,879	49	8,187	54
Switzerland	14,802	123	63,723	154
Taiwan	394	14	23,942	25
United Kingdom	46,600	355	80,744	348
Venezuela	749	22	6,243	29
Other	14,881	255	94,163	315
Total	13,343,669	3,144	2,331,924	3,953

[1] Includes radium, radium salts, and cobalt-60.

Table 15.—U.S. imports for consumption of uranium oxide, by countries

Country	1964		1965		1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada	1,890	$30,909	741	$13,606	635	$11,892	106	$2,051	2	$30
Germany, West	------	------	------	------	------	------	------	------	18	186
Japan	------	------	(1)	(1)	------	------	(1)	(1)	------	------
South Africa, Republic of	3,866	79,798	2,245	44,497	1,488	29,394	1,045	8,146	386	3,992
Spain	------	------	------	------	------	------	158	2,396	64	792
Total	5,756	110,707	2,986	58,103	2,123	41,286	1,309	12,593	470	5,000

[1] Less than ½ unit.

Table 16.—U.S. imports for consumption of cobalt-60, by countries

Country	1966		1967		1968	
	Curies	Value (thousands)	Curies	Value (thousands)	Curies	Value (thousands)
Canada	197,455	$791	379,575	$1,005	807,789	$1,390
United Kingdom	88	17	------	------	------	------
Total	197,543	808	379,575	$1,005	807,789	$1,390

ments, to West Germany and Switzerland, were enriched uranium in the form of UF_6 for fabrication abroad into reactor cores.

Radioactive isotopes, compounds, and elements (table 14) which were exported to 77 countries during 1968 decreased substantially in quantity (curies), but increased 26 percent in value. Exports of enriched uranium, uranium-233, plutonium, and heavy water during 1968, as reported by the AEC, are indicated in table 12.

As in the previous year, no uranium concentrates were imported for the AEC stockpile in 1968. All imports of uranium concentrate (table 15) during the year were for private industry use and came primarily from the Republic of South Africa (82 percent) and Spain (14 percent). Imports of cobalt-60 (Co^{60}) reported in table 16, more than doubled in quantity (curies) but increased only 38 percent in value.

In addition, 235 pounds of uranium compounds valued at $1,865 were imported from Sweden and 137 pounds of uranium metal valued at $1,785 were imported from Canada during the year.

WORLD REVIEW

Reports were published by the Organisation for Economic Co-Operation and Development (OECD) covering radioactive waste disposal, nuclear legislation, uranium production and demand, and prospects for nuclear energy in Western Europe.[27]

A world review of the status of fast-breeder reactors, shown in the accompanying tabulation, indicated that effective December 31, 1968, five reactors were operational, two were under construction, and three were in the design stage.[28]

Australia.—A detailed evaluation of recent developments in Australian uranium recovery operations was published during the year which described the extractive metallurgical operations, special equipment, and reagents employed.[29]

A report on the Australian uranium supply situation and of the Rum Jungle Uranium Project in particular was issued as Rum Jungle remained the country's sole ura-

---

[27] Organisation for Economic Co-Operation and Development. Illustrative Power Reactor Programmes: Prospects for Nuclear Energy in Western Europe. A report prepared by the European Nuclear Energy Agency, Paris, France, May 1968, 37 pp.

———. Legislation—Analytical Study: Nuclear Third Party Liability. A report prepared by the European Nuclear Energy Agency, Paris, France, 1967, 78 pp.

———. Radioactive Waste Disposal Operation Into the Atlantic—1967. A report prepared by the European Nuclear Energy Agency, Paris, France, September 1968, 74 pp.

———. Uranium: Production and Short Term Demand. A joint report prepared by the European Nuclear Energy Agency, Paris, France, and the International Atomic Energy Agency, Vienna, Austria, January 1969, 29 pp.

[28] Chemical Engineering. Nuclear Reactors Evolve Toward Fast-Breeders. V. 76, No. 3, Feb. 10, 1969, pp. 44–45.

[29] Woodcock, J. T. Ore Dressing Development in Australia, 1967. Australian Min., v. 60, No. 7, July 15, 1968, pp. 46–91.

Table 17.—Free world production of uranium oxide (U_3O_8), by countries [1] [2]

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
Argentina	37	50	--------	26	NA
Australia [e]	370	370	330	330	330
Canada	7,285	4,443	[r] 3,932	3,738	3,700
France [3]	[r] 1,331	[r] 1,421	[r] 1,542	1,592	1,445
Gabon	586	724	[e] 616	[e] 559	[e] 528
Malagasy Republic [e] [3]	[r] 196	65	65	55	--------
Portugal	[r] 20	42	46	[e] 55	NA
South Africa, Republic of	4,445	2,942	3,286	3,360	3,865
Spain [e]	[r] 77	[r] 67	66	77	77
Sweden [e]	10	20	50	61	61
United States	11,847	10,442	9,587	9,125	12,338
Total [4]	[r] 26,204	[r] 20,586	[r] 19,520	18,978	22,344

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Compiled from data available July 1969.

[2] Uranium is also believed to be produced in Czechoslovakia, East Germany, West Germany, Hungary, India, Italy, Japan, and U.S.S.R., but production data are not available.

[3] Contained in uranium ore.

[4] Total is of listed figures only.

Country and fast reactor	Status as of Dec. 31, 1968	Power (Mwt)[1]	Coolant	Fuel
France:				
Rapsodie	Operational	20	Sodium (Na)	Plutonium (Pu-) uranium (U) (oxide).
Phenix	In design	600	Na	Do.
Germany, West: Na-2	do	750	Na	Do.
Italy: PEC	do	116	Na	UO_2.
U.S.S.R.:				
BR-2	Operational	.1	Mercury (Mg)	Pu (metal).
BR-5	do	5	Na	Pu (oxide).
BOR-60	do	60	Na	Pu (oxide).
BN-350	Under construction	1,000	Na	Pu (oxide).
United Kingdom:				
Dounreay	Operational	60	Sodium-potassium (NaK)	U^{235} (metal).
PFR	Under construction	600	Na	Pu-U (oxide).

[1] Megawatts thermal.

nium-producing area during the year.[30] Early in 1969 Australia requested the assistance of the United States in conducting a feasibility study on using nuclear explosives to excavate a harbor on the coast of Western Australia.

Canada.—To supply the heavy water (D_2O) moderation material for the country's CANDU type natural uranium fueled reactors, several D_2O production plants were under construction. Since none of these plants were in operation during the year, the required heavy water was imported from the U.S.

Heavy water needs have been estimated at 16,000 tons by 1975, more than 43,000 tons by 1980, and over 80,000 by 1985.

During the year Eldorado Nuclear Ltd. (formerly Eldorado Mining and Refining Ltd.) began construction of a plant for uranium hexafluoride (UF_6) production at Port Hope, Ontario, which will have an initial capacity of 2,500 tons of UF_6 per year when the plant becomes operable in mid-1970.[31]

Reviews of significant Canadian uranium developments were reported which covered the major exploration, mine and mill development and production activities.[32]

Czechoslovakia.—Czechoslovakian production is believed to approach 10,000 tons of ore per year, most of which is processed to concentrate (U_3O_8) and sold to the U.S.S.R. for about $7.50 per pound.

France.—Commissariat à Énergic Atomique (CEA), the French Atomic Energy Commission, purchased about 450 pounds of plutonium from Atomic Energy of Canada Limited (AECL) for $1.5 million. This material will be shipped in the form of irradiated fuel to Mol, Belgium, where the plutonium will be extracted at the chemical reprocessing facilities of Société Europeenne pour be Traitement Chimique des Combustibles Irradies (EUROCHEMIC).

Seven reports issued by CEA, which described the uranium and plutonium processing facilities, uranium mining activities, nuclear fuel production and enrichment plants, isotope separation facilities, and

Company	Plant location	Capacity tons D_2O year	Start-up
Deuterium Corp. of Canada Ltd	Glace Bay, Nova Scotia	400+	1971
Canadian General Electric	Port Hawkesbury, N.S	420	1969
Atomic Energy Canada Limited	Douglas Point, Ontario	800	1972

---

[30] Stewart, J. R. Rum Jungle Uranium Project. South Africa Min. & Eng. J., v. 79, No. 3949, pt. 2, Oct. 11, 1968, pp. 844–850.

[31] U.S. Embassy, Ottawa, Canada. State Department Airgram A–1284. May 16, 1968, 2 pp.

[32] Atomic Energy of Canada Limited. 1967–1968 Annual Report. 1968, Ottawa, Canada, 45 pp.

Robertson, David S. Uranium—A Critical Situation. Western Miner, v. 41, No. 9, September 1968, pp. 22–26.

Robertson, David S., and Richard F. Douglas. The Uranium Exploration Situation. Min. Cong. J., v. 55, No. 1, January 1969, pp. 30–33.

Stephens, Fred S. Beaver Lodge—1968. Western Miner, v. 41, No. 9, September 1968, pp. 54–61.

Trigg, C. M. Uranium and the Beaverlodge District. Western Miner, v. 41, No. 9, September 1968, pp. 42–53.

Western Miner. The New Quirke Development. V. 41, No. 7, July 1968, pp. 38–56.

———. Uranium. V. 42, No. 3, March 1969, pp. 33–36.

Williams, R. M. Uranium. Canadian Min. J., v. 90, No. 2, February 1969, pp. 107–111.

Table 18.—Nuclear power reactors in the world, December 31, 1968

Country	Status							
	Operating		Under construction		Planned		Total	
	Mwe	No.	Mwe	No.	Mwe	No.	Mwe	No.
Canada	225	2	5,250	9	--------	-----	5,475	11
France	1,133	7	1,543	3	730	1	3,406	11
Germany, West	865	7	1,440	4	900	[1] 5	3,205	[1] 16
India	--------	-----	780	3	400	2	1,180	5
Italy	607	3	35	1	1,450	2	2,092	6
Japan	170	2	2,347	5	2,350	6	4,867	13
Spain	153	1	960	2	2,000	4	3,113	7
Sweden	64	1	2,525	4	--------	-----	2,589	5
Switzerland	--------	-----	1,006	3	1,750	4	2,756	7
U.S.S.R.	1,525	6	198	2	--------	-----	1,723	8
United Kingdom	4,145	13	6,316	6	3,800	2	14,261	21
United States	2,889	15	54,579	70	18,813	20	76,281	105
Other	118	[2] 2	4,136	[3] 8	4,136	[4] 7	5,704	17
Total	11,894	59	80,125	120	34,633	53	126,652	232

[1] Includes 3 reactors for which capacity has not yet been reported.
[2] Includes East Germany (1) and the Netherlands (1).
[3] Includes Argentina (1), Belgium (2), Bulgaria (1), Czechoslovakia (1), Hungary (2), and Pakistan (1).
[4] Includes Australia (1), Belgium (1), Finland (2), Mexico (1), Pakistan (1), and United Arab Republic (1).
Source: Canadian Nuclear Association, Nuclear Canada, v. 8, No. 1, January 1969, pp. 12–16.

Table 19.—Projected free world installed nuclear generating capacity and its breakdown by reactor type and region

(1,000 Mwe)

	1970	1975		1980	
		Low	High	Low	High
CONVERTERS					
Magnox type reactor:					
Western Europe	6.8	9.7	12.4	12.4	12.4
North America	-------	-------	-------	-------	-------
Rest of free world	.2	.2	.2	.2	.2
Total	7.0	9.9	12.6	12.6	12.6
Light water reactors:					
Western Europe	2.6	11.6	16.8	52.0	56.7
North America	12.8	61.9	68.3	110.0	155.0
Rest of free world	1.2	5.0	5.2	11.3	18.3
Total	16.6	78.5	90.3	173.3	230.0
Advanced gas-cooled reactors:					
Western Europe	0.9	6.7	11.7	19.0	37.2
North America	-------	-------	-------	-------	-------
Rest of free world	-------	-------	.6	1.5	2.5
Total	0.9	6.7	12.3	20.5	39.7
ADVANCED CONVERTERS					
Heavy water reactors:					
Western Europe	0.3	0.3	1.5	1.4	3.4
North America	.2	3.5	4.5	8.0	14.0
Rest of free world	.5	1.5	2.0	4.0	5.0
Total	1.0	5.3	8.0	13.4	22.4
High-temperature reactors:					
Western Europe	-------	0.3	0.7	3.1	7.9
North America	0.1	.4	1.3	10.0	15.0
Rest of free world	-------	-------	-------	-------	-------
Total	.1	.7	2.0	13.1	22.9
Grand total	25.6	101.1	125.2	232.9	327.6

Source: Organization for Economic Co-Operation and Development.

nuclear research centers operated by CEA, recently became available in English.[33]

Germany, West.—Following pilot plant studies of a new "nozzle separation" process for uranium enrichment, construction of a full-size enrichment stage was begun and is scheduled for completion in 1969. Although the new process avoids the membrane maintenance problems associated with the conventional gaseous diffusion process, the new process requires a much higher level of electrical power consumption, and is not believed capable of reaching the high enrichment levels required for the production of nuclear weapons.

A detailed review of German nuclear energy studies reported that work on steam- or sodium-cooled fast breeder reactors with uranium-plutonium fuels was conducted at Karlsruhe while high-temperature, helium-cooled reactors fueled with uranium/thorium were evaluated at Juelich.[34]

Hungary.—An agreement was signed between Hungary and the U.S.S.R., providing for the installation of two 400-Mwe light water nuclear reactors at a powerplant on the banks of the Danube River and scheduled to become operational by 1975.

India.—The Trombay Thorium Plant continued to supply UF_6 to the Bhabha Atomic Research Center during the year, as both of the 200-Mw boiling water reactors at the Tarapur Atomic Power Station near Bombay achieved criticality.

Uranium production from the Jaduguda project began during the year and is scheduled to reach a production level of 1,000 tons per day. At this level the project will produce about 200 tons of uranium concentrate (U_3O_8) per year.

Netherlands.—The United Kingdom, West Germany, and the Netherlands entered into a cooperative agreement to build a pilot plant gas-centrifuge type uranium enrichment plant by 1972 near The Hague. Although the size of this plant has not been definitely determined, some consideration is being given to a demonstration plant having a capacity between 20 and 100 tons per year. One of the major attractions of the gas-centrifuge system is that it would only consume about one-tenth as much electricity as a comparable-sized gaseous diffusion plant.

Niger.—The French Atomic Energy Commission (CEA) has found substantial uranium deposits in the Arhlit Province in fine-grained sandstones similar to those of the Colorado Plateau. Planned exploitation of these deposits includes open-pit mining operations and a pilot plant treatment mill having a design capacity of about 200 tons of uranium metal per year. Both these operations are scheduled for startup in 1970.[35]

Spain.—The 153-Mwe nuclear powerplant at Zorita, about 60 miles from Madrid, began operation on July 17, using Spanish uranium enriched in the United States.

The country's only ore processing mill is operated by the Spanish Nuclear Energy Board—Junta de Energia Nuclear (JEN) —at Andujar. M–1, JEN's nuclear fuel reprocessing plant at Madrid, was operated successfully during the year giving Spain its first quantity of plutonium.[36]

South Africa, Republic of.—When the Atomic Energy Act was amended to permit private ownership of uranium in the Republic of South Africa the mining industry established a common sales organization, Nuclear Fuels Corporation of South Africa (Pty.) Ltd. (NUFCOR), to be responsible for processing and marketing all uranium produced in the country which had previously been treated by Calcined Products Pty.[37] As in the previous year, all uranium production was a byproduct of gold mining operations. Reviews of the South African uranium mining, milling, and fuel production industries indicated that considerable experience has been acquired in these fields.[38]

---

[33] Commissariat a L'Energie Atomique. Centre D'Etudes Nucleaires de Grenoble (Grenoble Center of Nuclear Studies). Paris, France, 59 pp.

———. The Cadarache Nuclear Research Center. Paris, France, 60 pp.

———. Developments & Programs. June 1967, Paris, France, 63 pp.

———. The Fontenay Aux Roses Nuclear Research Center. Paris, France, 47 pp.

———. The La Hague Center. Paris, France, 1967, 39 pp.

———. The Marcoule Plutonium Production Center. Paris, France, 1965, 61 pp.

———. Pierrelatte Uranium Isotope Separation Plant. Paris, France, 31 pp.

[34] U.S. Embassy, Bonn, West Germany. State Department. Airgram A–14. Apr. 30, 1969, 83 pp.

[35] Moyal, M. Uranium Find in the Niger. Nuclear Engr. (London), v. 13, No. 143, April 1968, pp. 333–334.

[36] U.S. Embassy, Madrid, Spain. State Department. Airgram A–687. May 28, 1968, 7 pp.

[37] Bureau of Mines. Mineral Trade Notes. V. 65, No. 5, May 1968, p. 30.

The South African Mining and Engineering Journal. Uranium. V. 79, No. 3934, June 28, 1968, pp. 1642–1643.

Sweden.—The country's only uranium mining and concentration operation is located at Ranstad where the Aktiebolaget Atomenergi (a.-b. Atomenergi), the Swedish Atomic Energy Company, is considering expanding the capacity from about 130 tons per year to 650 to 13,000 tons of uranium per year.[39] It is expected that with the increased capacity and the recovery of byproduct mineral values the cost of uranium concentrate would decrease from the current rate of about $14 per pound of U_3O_8 to about $5 to $8 per pound.

Revised preditions of installed Swedish nuclear power indicated that the capacity would be 3,200 Mwe in 1970, 7,000 to 8,000 Mwe in 1980, and 18,000 Mwe by 1985.[40] Development work on plutonium enriched fuel continued during 1968 and a pilot plant for the manufacture of nuclear fuel is scheduled to become operational at Studsvik in 1969.

It is anticipated that all of Sweden's new reactors to be constructed and go onstream during the 1970's will be of the light-water type and that the low enriched uranium requirements for these reactors will be obtained from foreign suppliers.

United Kingdom.—Both the steam generating heavy water reactor (SGHWR) at Winfrith and the 250-Mwe fast reactor at Dounreay became operational during the year.[41] Reactivation of the Copenhurst diffusion plant, which had been shut down since 1962, was initiated during the year to provide enriched uranium for the country's growing nuclear power program.

Yugoslavia.—Successful uranium prospecting in Slovenia resulted in the recent opening of two open-pit mining operations between Idrija and Skofja Loka at Zirov Vrh. These deposits are expected to provide the fuel for Yugoslavia's first atomic power station which will be built in 1969 or 1970 at Krsko, Slovenia, on the Sava River between Zagreb and Ljublijana.

WORLD RESERVES

AEC estimated domestic uranium reserves minable at $8 per pound of U_3O_8 on December 31, 1968, at 70 million tons of ore with an average grade of 0.23 percent or 161,000 tons of U_3O_8. This was an increase from that of the previous year of 6 million tons of ore containing 13,000 tons of U_3O_8.[42]

A recently revised review of free world uranium reserves indicated that as a result of the renewed interest in uranium, the known free world reserves of uranium have increased.[43] The data from this report were tabulated as in table 20 for each of a series of price ranges and for 2 degrees of accuracy in each range. "Reasonably assured resources" was defined as material in known deposits of such grade, quantity, and configuration that it can be economically mined and processed under present technology within the given price range. "Possible additional resources" refers to material surmised to occur in unexplored extensions of known deposits and in undiscovered deposits of known or postulated uranium districts which is expected to be commercially exploitable in the given price range.

---

[38] Metal Bulletin. A Metal Bulletin Special Issue: South Africa. Summer 1968, 97–99.
The South African Mining and Engineering Journal. Nuclear Development in South Africa. V. 79, No. 3956, pt. 2, Nov. 29, 1968, pp. 1271–1273.
Union Corporation Ltd. (South Africa). Annual Report 1968, p. 48.

[39] Bureau of Mines. Mineral Trade Notes. V. 66, No. 3, March 1969, pp. 19–20.

[40] a.-b. Atomenergi. Press Bulletin. No. 4, June 4, 1969, Stockholm, Sweden, 6 pp.

[41] United Kingdom Atomic Energy Authority. 14th Annual Report and Accounts, 1967–68. London, July 24, 1968, 125 pp.

[42] Page 26 of work cited in footnote 10.

[43] Organisation for Economic Co-Operation and Development. Uranium Resources—Revised Estimates. A Joint Report of the European Nuclear Energy Agency, Paris, France, and the International Atomic Energy Agency, Vienna, Austria, December 1967, 25 pp.

Table 20.—Free-world estimated resources of uranium

(Thousand short tons, U_3O_8)

Price ranges per pound of U_3O_8	Less than $10		$10 to $15		$15 to $30	
Country	Reasonably assured resources	Possible additional resources	Reasonably assured resources	Possible additional resources	Reasonably assured resources	Possible additional resources
Angola	-----	-------	NA	15	NA	-------
Argentina	9	21	11	32	15	73
Australia	11	3	3	1	1	NA
Canada	200	290	130	170	100	300
Congo (Kinshasa)	6	NA	NA	NA	NA	NA
Denmark (Greenland)	NA	NA	5	NA	NA	NA
France	45	20	5	10	NA	NA
Gabon	4	4	NA	NA	NA	NA
India	NA	NA	3	1	24	61
Italy	2	NA	[1] 10	NA	[1] 20	NA
Japan	NA	NA	4	NA	NA	NA
Morocco [2]	6	NA	11	NA	8	NA
Niger	12	13	13	NA	NA	NA
Portugal	10	7	NA	12	NA	10
South Africa, Republic of [3]	205	15	65	35	55	70
Spain	11	NA	4	30	15	250
Sweden	NA	NA	350	50	150	200
United States:						
Conventional deposits	180	325	100	200	100	440
Byproduct of phosphate operations	120	25	50	-------	100	-------
Other [4]	5	20	6	NA	NA	NA
Total	826	743	770	556	588	1,404

NA Not available.
[1] Byproduct of zirconium, titanium and other minerals operations.
[2] Byproduct of phosphate operations.
[3] Byproduct of gold operations.
[4] Includes Turkey, West Germany, and Yugoslavia.

TECHNOLOGY

A revised text on current methods of locating, identifying, and mining uranium mineral deposits was prepared by the Bureau of Mines.[44] Bureau of Mines metallurgists evaluated newly developed methods of ion exchange (IX) uranium extractive metallurgy which indicated that specification-grade uranium concentrate could be efficiently recovered from copper waste dump leaching solutions for less than $8 per pound U_3O_8 by a combination of ion exchange resin and solvent extraction of liquid ion exchange techniques.[45] A joint study was conducted by the Bureau and Kennecott Copper Corp. to evaluate this system of countercurrent ion exchange on a pilot plant scale.

Investigations of the physical, mechanical, and irradiation properties of uranium and related nuclear materials were reviewed in quarterly reports prepared for the AEC.[46] Other periodic reports in this Technical Progress Review series covering the areas of power reactors, fuel-processing, isotopes, radiation, and nuclear safety continued to evaluate the latest findings in these areas.[47] A review of fundamental, basic, and applied research programs conducted for the AEC was also reported.[48]

Reports prepared by the Geological Survey (USGS) on behalf of the AEC evaluated the effects of nuclear explosives and radioactive waste disposal on river and ground-water tables, and of airborne radioactivity measurements as an aid to mapping.[49] A comprehensive report on uranium resource evaluation was conducted for the AEC Division of Raw Materials at Grand Junction, Colo.[50] Further studies of the geology of New Mexico indicated appreciable uranium mineralization in the Burro Mountains.[51]

---

[44] Bureau of Mines. Prospecting and Exploring for Radioactive Minerals: Supplement to Facts Concerning Uranium Exploration and Production. Inf. Circ. 8396, 1968, 36 pp.

[45] George, D. R., J. R. Ross, and J. D. Prater. Byproduct Uranium Recovered with New Ion Exchange Techniques. Mining Engineering, v. 20, No. 1, January 1968, pp. 73–77.

[46] Simmonds, E. M., S. W. Porembka, Jr., and D. L. Keller. Reactor Materials. U.S. Government Printing Office, vol. II, Nos. 1–4, 1968, 283 pp.

[47] Argonne National Laboratory. Reactor and Fuel-Processing Technology. U.S. Government Printing Office, v. II, Nos. 1–4, 1968, 238 pp.
Baker, P. S., A. F. Rupp, and Associates. Isotopes and Radiation Technology. U.S. Government Printing Office, v. 5, Nos. 1–4, 1968, 362 pp.
Cottrell, W. B., W. H. Jordan, and J. P. Blakely. Nuclear Safety. U.S. Government Printing Office, v. 9, Nos. 1–6, 1968, 556 pp.

[48] U.S. Atomic Energy Commission. Fundamental Nuclear Energy Research—1968. January 1969, 368 pp.

Cladding and structural material requirements for fast-breeder reactors and for plutonium-fueled reactors were reviewed.[52]

Two comprehensive reviews evaluated the embrittlement effects on structural and cladding materials caused by neutron irradiation.[53]

The joint AEC-NASA nuclear rocket program, continued to evaluate nuclear rockets to provide the basic technology for development of a nuclear stage for a space vehicle. Because a nuclear propelled rocket has significant advantages over a chemical propellant rocket, especially for deep-space shots to Mars and beyond, interest in the AEC-NASA nuclear rocket program continued.[54]

Special heat absorbing cermet control rods have been developed by Douglas United Nuclear, Inc. (DUN), Richland, Wash., which may eliminate the need to cool reactor control rods. The dysprosium oxide-nickel (Dy_2O_3—Ni) cermet which absorbs neutrons readily can withstand the heat of a reactor core without change in size due to temperature or the effect of extended neutron irradiation.

A review of nuclear fuels for the 1970's concluded that for some years to come the heavy water-moderated, natural uranium reactors (Canadian CANDU type) will offer the lowest fueling cost and highest uranium utilization in those countries which are unable to obtain enriched uranium for their nuclear fuel.[55]

The manmade element californium-252 (cf^{252}), an intense neutron emitter became available in extremely limited quantities during the year for use in locating mineral and oil deposits as well as ground-water sources.[56] The sale price of cf^{252} would be $450 billion per pound if a pound were available. The AEC's quoted price for the purchase of this radioactive element is $100 for one-tenth of a microgram (one-ten-millionth of a gram).

Because of its promise for producing both the electrical power and the water required throughout the world, the evaluation of nuclear desalinization plants continued.[57]

Reviews of the application of radioisotopes in the chemical processing industry indicated that the future for these materials was limited only by the requirements of safety associated with their radioactivity.[58]

---

[49] Carrigan, P. H. Jr. Radioactive Waste Dilution in the Clinch River, Eastern Tennessee: Transport of Radionuclides by Streams. U.S. Geol. Survey Prof. Paper 433–G, 1968, 9 pp.

Piper, Arthur M. Potential Applications of Nuclear Explosives in Development and Management of Water Resources—Preliminary Canvass of the Ground-Water Environment. U.S. Geol. Survey, TEI–873, 1968, 173 pp.

Pitkin, James A. Airborne Measurements of Terrestrial Radioactivity as an Aid to Geologic Mapping: Geophysical Field Investigations. U.S. Geol. Survey Prof. Paper 516–F, 1968, 29 pp.

[50] Bostick, N. H., A. L. Lange, R. P. Farquhar, and I. H. Derman. Resource Evaluation and Geologic Data Processing Systems for Sedimentary Host Rocks of Uranium Ore. Stanford Research Inst., Menlo Park, Calif., AEC Contract AT–(04–3)–115, Sept. 25, 1968, 382 pp.

[51] Gillerman, Elliot. Uranium Mineralization in the Burro Mountains, New Mexico. Econ. Geol., v. 63, No. 3, May 1968, pp. 239–246.

[52] Allio, R. J., and J. B. Roll. Plutonium Fuels Technology. J. Metals, v. 20, No. 2, February 1968, pp. 14–18.

Kangilaski, Mihkel, and Richard A. Wullaert. Cladding Materials for Nuclear Reactor Fuel. Battelle Tech. Rev., Columbus, Ohio, v. 17, No. 3, March 1968, pp. 21–27.

[53] Kangilaski, M. The Effects of Neutron Radiation on Structural Materials. Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. June 30, 1967, 245 pp. N 68–16876.

Younger, Charles L., and Gilbert N. Wrights. Effect of 10^{20}-Neutron-Per-Square-Centimeter Irradiation on Embrittlement of Polycrystaline Tungsten. Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., July 1968, 57 pp.

[54] Rom, Frank E. Nuclear Rocket Propulsion. Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., NASA TM X–1685, November 1968, 37 pp.

U.S. Atomic Energy Commission/National Aeronautics and Space Administration. Joint News Release L–166, July 19, 1968, 2 pp. Pages 155–161 of work cited in footnote 11.

[55] Fortune, R. F. Nuclear Fuels for the 70's. J. (Montreal, Canada), v. 51, No. 5, May 1968, 8 pp.

[56] U.S. Atomic Energy Commission. Press Release L–182, Aug. 6, 1968, 4 pp.

———. Press Release S–38–68, Oct. 22, 1968, 11 pp.

———. Press Release S–40–68, Oct. 22, 1968, 11 pp.

Chemical Week. Ahead? Transuranium by the Ton. V. 102, No. 6, Feb. 6, 1968, p. 49.

Pages 4 and 39–42 of work cited in footnote 10.

[57] Atomic Energy Commission/U.S. Department of the Interior. Joint Press Release L–234. Oct. 1, 1968, 2 pp.

Starmer, R., and F. Lowes. Nuclear Desalting. Future Trends and Today's Costs. Chem. Eng., v. 75, No. 19, Sept. 9, 1968, pp. 127–142.

[58] Baker, Philip S. Radioisotopes in Chemical Processes. Chem. Eng., v. 75, No. 6, Mar. 11, 1968, pp. 179–186.

Lamade, Wanda. Chemical to Nuclear. Ag. Chem., v. 23, No. 5, May 1968, pp. 18–20.

Shipments of spent fuel elements, a relatively minor economic step in the nuclear fuel cycle, are subject to the most stringent regulations to protect the public from excess radioactivity. The problems associated with these shipping containers, including special design, construction, and radiation shielding, were reviewed.[59]

As a result of the strict AEC regulations limiting the concentration of radionuclides in liquid effluents from uranium mill wastes, special methods have been developed to stabilize the tailings piles and to provide for the disposal of liquid and solid wastes primarily as precipitated salts.[60] Another method of disposing of radioactive wastes has been developed as part of the Waste Solidification Engineering Prototype (WSEP) program conducted by Battelle-Northwest, Richland, Wash., in which the wastes are converted into a compact glassy form and cast into steel pots.[61] In addition, two other methods of nuclear waste disposal, spray solidification and pot solidification, are being evaluated.

In the chemical extraction of polonium-210, a considerable amount of contaminated waste is generated which is discarded as an acid waste solution that is neutralized, packed in drums, and buried.[62]

The use of nuclear irradiation to treat sewage and industrial wastes is being evaluated by the Metropolitan Sanitary District of Greater Chicago as a method to cope with the ever-increasing amounts of sewage which are a result of rapidly growing population and industrial facilities.

---

[59] Rollins, Jack D., and Elmer C. Lusk. Shipping Containers for Irradiated Reactor Fuels. Battelle Tech. Rev., Columbus, Ohio, v. 17, No. 8, August 1968, pp. 9–15.

[60] Beverly, R. G. Unique Disposal Methods are Required for Uranium Mill Waste. Min. Eng., v. 20, No. 6, June 1968, pp. 52–56.

[61] Chemical Week. V. 101, No. 24, Dec. 9, 1967, p. 77.

[62] Althoff, Robert F. Isotope-Extraction Process Copes With Radioactive Waste. Chem. Eng., v. 75, No. 6, Mar. 11, 1968, pp. 150–152.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-740/77

Vanadium

By Gilbert L. DeHuff[1]

As indicated by price, demand for vanadium was under the control of supply and the vanadium shortage was over. Some occasional rumblings to the contrary appear to have resulted from momentary problems of individual suppliers or consumers—a matter of distribution and timing. All this was in the environment of no Government sales for the second year in succession. Both demand and domestic production continued at high levels. Imports of ferrovanadium were more than those of any previous year. Exports continued to decline but still exceeded total vanadium imported.

Legislation and Government Programs.—There were no sales or offerings of surplus Government vanadium stocks in 1968. As of December 31, 1968, the national stockpile inventory was unchanged from that of a year earlier—5,609 short tons of vanadium with 1,200 tons of this quantity in ferrovanadium and the remainder contained in vanadium pentoxide.

Table 1.—Salient vanadium statistics

(Short tons of contained vanadium)

	1964	1965	1966	1967	1968
United States:					
Production:					
Ore and concentrate:					
Recoverable vanadium [1]	4,362	5,226	5,166	4,963	6,483
Value thousands	$13,061	$18,284	$22,210	$21,331	$23,143
Vanadium pentoxide recovered	5,049	6,160	6,496	5,921	6,149
Consumption	3,550	4,708	5,481	[r] 5,245	5,495
Exports:					
Ferrovanadium and other vanadium alloying materials (gross weight)	103	220	482	351	278
Vanadium ores, concentrate, oxides, and vanadates	1,231	928	886	788	463
Imports (general):					
Ferrovanadium (gross weight)	466	51	8	14	621
Ore and concentrate	12	---------	72	42	31
World: Production	8,573	9,834	10,029	10,509	12,562

[r] Revised.

[1] Measured by receipts of uranium and vanadium ores and concentrates at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

DOMESTIC PRODUCTION

Although production began from the Wilson Springs, Ark., deposit of Union Carbide Corp., and vanadium continued to be recovered from ferrophosphorus, western uranium-vanadium ores were again the principal domestic source of supply. Some fly ash, boiler scrapings, oil residues, spent catalysts, and imported vanadiferous slags, were included in the feed at western processing plants.

Four mills recovered vanadium from domestic uranium-vanadium and vanadium uranium ores: American Metal Climax, Inc., Grand Junction, Colo.; Atlas Minerals, Division of Atlas Corp., Moab, Utah; Foote Mineral Co., Shiprock, N. Mex.; and Union Carbide Corp., Rifle, Colo. In June, Foote Mineral Co. closed its Shiprock mill and transferred mine leases to American Metal Climax for operation on a royalty basis. A fire on Christmas Day at the Moab plant of Atlas Corp. was expected to put that facility out of production for a good portion of 1969.

---

[1] Physical scientist, Division of Mineral Studies.

Kerr-McGee Corp., Soda Springs, Ida. increased its recovery of vanadium from ferrophosphorus. However, Vitro Minerals & Chemical Co. Division, Vitro Corporation of America, Salt Lake City, Utah, recovered vanadium from ferrophosphorus only until July 7 when the plant closed for the remainder of the year.

Table 2.—Recoverable vanadium of domestic origin produced in the United States, by States

(Short tons of contained vanadium)

	1964	1965	1966	1967	1968
Colorado	3,312	4,017	3,697	3,317	3,492
Utah	405	387	353	471	563
Arizona and other States [1]	645	822	1,116	1,175	2,428
Total	4,362	5,226	5,166	4,963	6,483

[1] Includes Arkansas, 1968; Idaho, 1964–68; New Mexico, 1964–68; North Dakota, 1965; Oregon, 1964; South Dakota, 1964–67, Wyoming, 1964–67.

Table 3.—Mine production and recoverable vanadium of domestic origin produced in the United States

(Short tons)

Year	Mine production [1]	Recoverable vanadium [2]
1964	5,184	4,362
1965	5,641	5,226
1966	5,685	5,166
1967	5,088	4,963
1968	7,105	6,483

[1] Measured by receipts of uranium and vanadium ores and concentrates at mills, vanadium content.

[2] Recoverable vanadium contained in uranium and vanadium ores and concentrates received at mills, plus vanadium recovered from ferrophosphorus derived from domestic phosphate rock.

Table 4.—Production of vanadium pentoxide in the United States [1]

(Short tons)

Year	Gross weight	V_2O_5 content
1964	9,775	9,013
1965	11,498	10,996
1966	11,955	11,595
1967	10,915	10,569
1968	12,105	10,976

[1] Includes vanadium pentoxide and metavanadate produced directly from all domestic ores plus that obtained from imported slag and small byproduct quantities from imported chromium ores.

CONSUMPTION AND USES

Domestic consumption of vanadium contained in ferrovanadium, other vanadium alloys, metal, and some chemicals increased over the 5,245-ton final total figure reported for 1967. Consumption increased appreciably for high-strength low-alloy constructional steels, and for steel line pipe used in laying cross-country natural gas transmission lines, but demand for tool steels was off. Lengthy strikes in the titanium industry were responsible for a large drop in consumption of vanadium in the nonferrous alloy category.

Table 5.—Consumption and consumer stocks of vanadium materials in the United States

(Short tons of contained vanadium)

Type of material	1967		1968	
	Consumption [r]	Ending stocks	Consumption	Ending stocks
Ferrovanadium [1]	4,305	[r] 1,007	4,712	783
Oxide	153	[r] 41	155	20
Ammonium metavanadate	115	15	94	13
Other [2]	672	129	534	161
Total [3]	5,245	[r] 1,193	5,495	977

[r] Revised.

[1] Includes other vanadium-carbon-iron alloys.

[2] Consists principally of vanadium-aluminum alloy, and relatively small quantities of other vanadium alloys and vanadium metal.

[3] Data may not add to totals shown due to independent rounding.

Table 6.—Consumption of vanadium in the United States by end uses

(Short tons of contained vanadium)

End use	1967 [r]	1968
Steel (ingots and castings):		
High-speed and tool	748	610
Stainless	39	50
Alloy (excluding stainless and tool)	2,106	2,591
Carbon	828	1,092
Other steel	5	7
Cast irons	54	57
Cutting and wear resistant materials	13	16
Welding and hardfacing rods and materials	12	12
Magnetic alloys	4	6
Nonferrous alloys [1]	614	459
Chemical and ceramic uses	132	168
Miscellaneous and unspecified	693	426
Total [2]	5,245	5,495

[r] Revised.
[1] Principally titanium-base alloys.
[2] Data may not add to total shown due to independent rounding.

STOCKS

Producer's stocks of vanadium as fused oxide, precipitated oxide, vanadiferous slag, metavanadate, metal, alloys, and chemicals, totaled 2,828 short tons of contained vanadium at yearend. This quantity is in addition to the consumer's inventory reported in table 5, and compares with 2,231 tons at the end of 1967.

PRICES

Prices for technical-grade vanadium pentoxide continued to decline. Metals Week quotations for export merchant or dealer pentoxide opened the year at $1.05 to $1.15 per pound of contained V_2O_5, f.a.s. U.S. shipping port. At yearend the quote was 95 cents, same basis, but it appeared that this was nominal since indications were that some sales had been made at lower prices. The contract price of South African pentoxide for the United Kingdom and continental Europe was down to the equivalent of 90 U.S. cents for the final quarter of the year. It was announced that this would continue unchanged for the first quarter of 1969. The availability of vanadiferous slag in quantity from the U.S.S.R. was a depressing factor.

The price of Carvan remained at $2.46 per pound of contained vanadium throughout the year. Quotations for the new alloy, Solvan (see Technology), appeared in September at this price, and continued without change to the end of the year. A price of $2.90 per pound of contained vanadium, packed, f.o.b. shipping point with freight equalized to nearest main producer, prevailed through the year for all grades of ferrovanadium, although some spot sales reportedly were made at lower prices and imported alloy was apparently being sold near the end of the year at prices competitive with Carvan and Solvan. The 90-percent grade of vanadium metal sold for $3.45 per pound of contained vanadium. Prices for high-purity vanadium (99.3 to 99.99 percent) ranged from $33 to $2,000 per pound depending on the degree of purity and the form in which sold.

Effective July 1, Union Carbide Corp. increased its prices for several vanadium chemicals used in producing chemical catalysts, coloring additives, and color phosphors. Its 98-percent flake pentoxide became $1.39; 99.2-percent granular pentoxide, $1.53; technical grade ammonium metavanadate $1.66; and high-purity ammonium metavanadate, $1.95. All of these prices were per pound of material, f.o.b. Grand Junction, Colo.

FOREIGN TRADE

The average declared value for exports of ore, concentrates, and technical-grade oxides, was $1.19 per pound of contained vanadium pentoxide in 1968, compared with $1.44 in 1967. The average declared value of ferrovanadium exported in 1968 was $1.90 per pound of alloy, compared with $1.99 in 1967. Quantities for both categories of exports decreased for the second year in succession.

Imports classified as ore and concentrates in 1968 contained 55 short tons of vanadium pentoxide and came from Canada and the Netherlands Antilles. In addition, vanadiferous slag (classified as metal-bearing residues) was imported from Chile, the Republic of South Africa, and apparently from the U.S.S.R. also.

Table 7.—U.S. exports of vanadium, by countries

(Thousand pounds and thousand dollars)

Destination	Ferrovanadium and other vanadium alloying materials containing over 6 percent vanadium (gross weight)				Vanadium ore, concentrates, pentoxide, vanadic acid, vanadium oxide, and vanadates (except chemically pure grade) (vanadium content)			
	1967		1968		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
Argentina	-------	-------	-------	-------	3	$7	-------	-------
Australia	-------	-------	-------	-------	64	148	14	$25
Austria	-------	-------	-------	-------	361	956	179	387
Belgium-Luxembourg	-------	-------	-------	-------	-------	-------	318	649
Brazil	6	$11	-------	-------	1	3	-------	-------
Canada	448	883	295	$562	31	76	24	58
Chile	-------	-------	1	2	-------	-------	-------	-------
Colombia	(1)	1	1	1	-------	-------	-------	-------
Czechoslovakia	-------	-------	-------	-------	75	276	-------	-------
France	-------	-------	(1)	(1)	296	703	64	154
Germany, West	-------	-------	-------	-------	262	626	63	134
India	43	89	59	143	-------	-------	35	64
Italy	-------	-------	-------	-------	37	96	-------	-------
Japan	-------	-------	-------	-------	264	696	144	303
Mexico	141	285	61	108	4	10	5	13
Netherlands	20	28	6	15	-------	-------	-------	-------
Netherlands Antilles	-------	-------	-------	-------	(1)	(1)	(1)	1
Rhodesia, Southern	-------	-------	-------	-------	-------	-------	7	13
Spain	-------	-------	-------	-------	2	2	-------	-------
Sweden	2	6	-------	-------	144	361	22	46
Turkey	-------	-------	15	32	-------	-------	-------	-------
United Kingdom	-------	-------	-------	-------	31	83	50	125
Venezuela	42	95	117	189	-------	-------	-------	-------
Total	702	1,398	555	1,052	1,575	4,043	925	1,972

[1] Less than ½ unit.

Table 8.—U.S. imports of ferrovanadium, by countries

(Thousand pounds and thousand dollars)

Country	General imports				Imports for consumption			
	1967		1968		1967		1968	
	Gross weight	Value	Gross weight	Value	Gross weight	Value	Gross weight	Value
Austria	-------	-------	531	$725	-------	-------	531	$725
Belgium-Luxembourg	12	$24	61	111	-------	-------	52	93
France	-------	-------	5	9	-------	-------	5	9
Germany, West	15	37	567	796	15	$37	527	735
Sweden	-------	-------	77	137	-------	-------	77	137
Total	27	61	1,241	1,778	15	37	1,192	1,699

WORLD REVIEW

In addition to the production reported in table 9, the U.S.S.R. and Chile produced vanadiferous slags from iron ores, and some other countries had relatively small unreported vanadium production from secondary sources or of a byproduct nature. Canada has recovered vanadium pentoxide from oil residues since 1965. Beginning somewhat earlier, Japan has been producing ammonium metavanadate and/or vanadium pentoxide from waste sulfuric acid resulting from the production of titanium dioxide. West Germany recovered a vanadium product from South-West African lead-vanadium concentrates (credited in table 9 to South-West Africa), and probably from other unreported byproduct or secondary sources as well. It is presumed that France still recovers vanadium pentoxide as a byproduct of bauxite processing, and possibly from other sources. Italy and Sweden may also have recovered vanadium from some of the above sources in 1968 as well as earlier.

Finland.—The country's only vanadium producer, government-owned Otanmaki Oy, was amalgamated with Rautaruukki Oy, a government-owned iron and steel firm, with operations continuing under the latter name. Although the merger was not formally accomplished until the end of the year, the effective date for all practical purposes was June 30.

Table 9.—World production of vanadium in ores and concentrates, by countries [1] [2]

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
Argentina	3	--------	--------	--------	--------
Finland	1,084	1,063	1,069	1,292	1,321
Mexico	--------	1	--------	--------	--------
Norway [e]	740	750	730	[r] 816	937
South Africa, Republic of	1,282	1,519	1,711	[r] 2,115	2,498
South-West Africa (recoverable vanadium)	1,102	1,275	1,353	[e] [r] 1,323	[e] 1,323
United States (recoverable vanadium)	4,362	5,226	5,166	4,963	6,488
Total [3]	8,573	9,834	10,029	[r] 10,509	12,562

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Figures for Finland and Republic of South Africa are for vanadium in vanadium pentoxide. The U.S.S.R. had vanadium production, but data are insufficient for estimation.

[2] Compiled mostly from data available May 1969.

[3] Total is of listed figures only; no undisclosed data included.

India.—Reserves of vanadiferous titaniferous magnetite in the Singbhum district of Bihar and adjoining areas of the Mayurbhanj district of Orissa were reported to total 22 million tons grading 1.5 to 2.5 percent vanadium pentoxide and 10 to 16 percent titanium dioxide. Based on research at the National Metallurgical Laboratory at Jamshedpur, a pilot plant was set up for treating 1 ton of ore per day to produce vanadium pentoxide. The laboratory of the Indian Bureau of Mines conducted pyrometallurgical research on recovery of vanadium from alumina plant sludge.[2]

Japan.—For the purpose of purchasing and stockpiling certain metals, including vanadium, Japan Rare Metals Co. was formed by a consortium of 35 steelmakers, ferroalloy producers, and nickel smelters. It was expected to be Japan's agency for purchasing U.S. surplus stockpile material as it is made available.[3]

South Africa, Republic of.—The first shipment of vanadiferous slags from the Highveld Steel and Vanadium Corp. Ltd., iron-steel-vanadium plant went to Europe in August. The first shipment to the United States, 3,000 tons, left in October destined for Foote Mineral Co. Under a licensing agreement with the Norwegian ferrovanadium producer, Christiania Spigerverk, world rights outside Norway to Spigerverk's process for reducing vanadiferous slags directly to ferrovanadium were acquired by Highveld. September was the second best month on record for sales of vanadium pentoxide from Highveld's Vantra Division. This followed a period of poor demand which had resulted in shutting down the division's two rotating kilns and a consequent reduction in production of approximately 20 percent. Capacity of the plant exceeds 3,000 short tons of vanadium pentoxide per year, analyzing better than 99 percent purity. Union Carbide's subsidiary, Ucar Minerals Corp., produced vanadium pentoxide in 1968, as well as 1967, at the former Federale property at Bon Accord, near Pretoria. Capacity of the plant was about 1,000 to 1,500 tons of vanadium pentoxide per year, utilizing ore from a seam of titaniferous magnetite of the Bushveld complex. The pentoxide product was exported to the United Kingdom and Europe.

---

[2] Metal Bulletin (London). No. 5267, Jan. 23, 1968, p. 25.

[3] Metals Week. V. 39, No. 28, July 8, 1968, p. 7.

South-West Africa.—Shaft sinking at the Berg Aukas mine, near Grootfontein, was completed in September to its objective, 1,685 feet below surface or 50 feet below the 17 level. Crosscutting was planned to investigate good indications of vanadium ore disclosed by drilling between the 11 and 14 levels.

U.S.S.R.—A large new plant for production of ferrovanadium from vanadiferous slags, derived from Ural magnetites, was reportedly under construction at the Serov steel plant. It appeared probable that some method of direct reduction would be employed.[4]

TECHNOLOGY

In continuing research with high-purity vanadium metal, the Bureau of Mines developed a two-cycle, molten-salt electrorefining procedure to produce metal of 99.99 percent purity from commercially available calcium-reduced briquets analyzing 99.5 percent vanadium. High-ductility and substantial reduction in hardness were accomplished in achieving this objective. Electrorefining was conducted in a helium atmosphere using a 12-inch-diameter cell containing 80 pounds of chloride electrolyte of the following percentage weight composition: 51 KCl, 41 LiCl, and 8 VCl_2. The calcium-reduced briquet served as anode in the first cycle of refining, whereas the products obtained were used as the anode material for the second cycle. In each case, the refined product was deposited on a molybdenum cathode rod. The work was on a 1-pound batch scale and current consumption was approximately 500 ampere-hours per pound. The vanadium crystals obtained from the electrorefining contained approximately 200 parts per million (ppm) of alkali metal chlorides. By melting in an inert atmosphere on a chilled copper plate, a consolidated ingot was produced containing less than 5 ppm of alkali metals.[5] This high-purity metal is of interest as a likely material for fuel containers in the breeder type of nuclear reactor now under development.

In other Bureau work, vanadium trichloride was prepared and subsequently reduced with molten magnesium to produce vanadium metal with interstitial impurities ranging from 820 to 1,330 ppm. It appeared that this procedure was capable of expansion to a larger scale than is possible with the regular commercial bomb-reduction process.[6] The heat of formation of vanadium trichloride was determined at 298.15° K, and compared with the published results of earlier investigators.[7]

Boron additions to vanadium were investigated and found to restrict grain growth with increasing temperature. The work suggested that boron might be a useful addition to vanadium-base alloys for high-temperature applications.[8]

A new high-density vanadium ferroalloy was patented and marketed by Foote Mineral Co. under the tradename Solvan. A smelted and cast ferroalloy of high iron content, it is reportedly obtained by direct reduction of high-vanadium slag, and is claimed to be particularly suited for use in the production of high-strength low-alloy steels. Its specifications give a vanadium content of 25 to 30 percent; silicon, 5.0 percent maximum (low-silicon Solvan is offered with a silicon content of approximately 0.8 percent); and carbon, 0.30 percent maximum. It has a low oxygen content and a manganese content of 3 to 4 percent. Besides having high density and being low in nonmetallic inclusions, its advantages are stated to include rapid solubility, high vanadium recovery, and relatively low cost.

---

[4] Metal Bulletin (London). No. 5296, May 7, 1968, p. 18.

[5] Lei, K. P., and T. A. Sullivan. High-Purity Vanadium. J. Less-Common Metals (Amsterdam, Netherlands), v. 14, No. 1, January 1968, pp. 145–147.

[6] Ferrante, M. J., F. E. Block, and J. L. Schaller. High-Purity Vanadium by Metallothermic Reduction of Vanadium Trichloride. BuMines Report of Inv. 7145, 1968, 22 pp.

[7] Mrazek, R. V., D. W. Richardson, H. O. Poppleton, and F. E. Block. Determination of the Heat of Formation of Vanadium Trichloride. BuMines Rept. of Inv. 7096, 1968, 15 pp.

[8] Iverson, H. G., D. R. Mathews, and J. S. Winston. Effects of Boron and of Boron With Carbon on the Mechanical Properties of Vanadium. BuMines Rept. of Inv. 7118, 1968, 18 pp.

At the Witbank plant of Transvaal Vanadium Co. (Pty.) Ltd., in the Republic of South Africa, titaniferous magnetite from the Kennedy's Vale mine is crushed, ground, dewatered, and salt-roasted in rotary kilns or multiple hearth furnaces using either sodium chloride or a mixture of sodium carbonate and sodium sulfate. The soluble vanadium salts formed, essentially sodium vanadate, are then water-leached from the resulting calcines. Addition of ammonium salts to the pregnant solution precipitates ammonium metavanadate from which three products are prepared for shipment: Pure ammonium metavanadate for use as a catalyst by the chemical industry; catalyst grade vanadium pentoxide (red oxide) to be used mainly as a catalyst for converting sulfur dioxide to sulfur trioxide in contact sulfuric acid plants; and fused vanadium pentoxide for conversion to ferrovanadium. Drying slowly at low temperatures (50° C), followed by screening, produces the metavanadate as a fine white powder which is packed in plastic-lined steel drums. By calcining the metavanadate filter cake at +400° C, ammonia is driven off with the catalyst grade oxide left as a fine red powder. From this, the fused vanadium pentoxide is produced by melting in an electrically heated furnace. Both pentoxide products are packed in steel drums for shipment.[9]

A flowsheet for obtaining 99.5 percent vanadium pentoxide from the high-grade vanadiferous slags produced by Highveld Steel and Vanadium Corp. Ltd. was tested in a company pilot plant at Witbank, Republic of South Africa. The slag, containing small quantities of chromium and appreciable quantities of silica, is salt-roasted, followed by water-leaching of the vanadium values along with some of the chromium and silica. Upon acidification with hot hydrochloric acid to a pH of about 2, a sodium hexavanadate precipitate (red cake) is obtained which upon filtering and drying contains from 85 to 94 percent vanadium pentoxide and 4 to 11 percent sodium-oxide. By use of this long-established commercial practice vanadium is separated from the chromium and silica. Modification of a Bureau of Mines procedure[10] is then used to obtain high-purity vanadium pentoxide. The washed red cake is dissolved in a hot ammoniacal solution of ammonium chloride and upon cooling ammonium metavanadate is precipitated. By heating to a temperature exceeding 450° C, the ammonia is driven off leaving vanadium pentoxide as a powder which is fused and flaked for shipment. Formation of lower oxides of vanadium is prevented by passing the proper quantity of air over the charge during deammoniation.[11]

---

[9] Guise-Brown, A. L., and M. G. Atmore. The Recovery of Vanadium Pentoxide at Transvaal Vanadium (Pty.), Ltd. J. South African Inst. Min. and Met. (Johannesburg), v. 68, No. 9, April 1968, pp. 397–404.

[10] Chindgren, C. J., L. C. Bauerle, and J. B. Rosenbaum. Preparing Metal-Grade Vanadium Oxide from Red Cake and Mill Solutions. BuMines Rept. of Inv. 5937, 1962, 14 pp.

[11] Douglas, W. D., H. J. Bovey, and D. A. Temple. A Process for the Production of High Grade Vanadium Pentoxide From Solutions Containing Chromium and Silica. J. South African Inst. Min. and Met. (Johannesburg), v. 68, No. 9, April 1968, pp. 385–396.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/185

Vermiculite

By William N. Hale [1]

The market for vermiculite in the United States advanced during 1968 following increased construction activity. Production and value of crude vermiculite were 14 percent higher than in 1967. Exfoliated vermiculite output and value increased 18 percent over the 1967 figures. The average unit value of crude vermiculite increased $0.09 per ton, but the average value per ton of exfoliated vermiculite declined $0.24.

DOMESTIC PRODUCTION

Crude Vermiculite.—Four companies reported production from five mines in four States. W. R. Grace & Co., Zonolite Division, with mines in Laurens County, S.C., and Lincoln County, Mont., continued to be the principal producer. Other producers were Solomon's Mines, Inc., from an operation in Maricopa County, Ariz.; Patterson Vermiculite Co., from a mine in Laurens County, S.C.; and Perlite Producers, Inc., from a property in Llano County, Tex.

Exfoliated Vermiculite.—Twenty-four companies operating 49 plants exfoliated 216,418 tons of vermiculite, an increase of 18 percent over the 1967 tonnage. W.R. Grace & Co., Zonolite Division, continuing as the largest producer, operated 22 plants in 20 States. Over 55 percent of exfoliated vermiculite production came from operations in eight States. The eight major producing States in order of output and the respective number of plants in each State were as follows: South Carolina, 2; Texas, 4; California, 3; Florida, 4; Illinois, 3; Pennsylvania, 2; New Jersey, 2; Minnesota, 3.

Table 1.—Salient vermiculite statistics

	1964	1965	1966	1967	1968
United States:					
Sold and used by producers:					
Crude........thousand short tons..	226	249	262	255	290
Value........thousand dollars..	$3,613	$4,460	$4,954	$4,974	$5,684
Average value per ton..........	$15.99	$17.91	$18.91	$19.51	$19.60
Exfoliated.....thousand short tons..	177	177	193	180	213
Value........thousand dollars..	$13,862	$13,424	$15,130	[r] 14,278	$16,845
Average value per ton..........	$78.32	$75.84	$78.39	[r] $79.32	$79.08
World: Production crude thousand short tons..	343	380	382	370	417

[r] Revised. NA Not available.

CONSUMPTION AND USES

Producers of exfoliated vermiculite reported the following end-use percentages for 1968 (comparable 1967 figures are in parentheses): aggregates (concrete, plaster, cement), 40 percent (43 percent); insulation (loose fill, block, pipe covering, packing), 40 percent (36 percent); agriculture (horticulture, soil conditioning, fertilizer carrier, litter), 16 percent (17 percent); and miscellaneous, 4 percent (4 percent).

---

[1] Geologist, Albany Office of Mineral Resources, Albany, Oreg.

PRICES

The average value of crude vermiculite, cleaned at the mine, was $19.60 per short ton. The exfoliated product average value, f.o.b. producers plant, was $79.08 per short ton. For the past 5 years, 1964–68, the price of crude vermiculite increased over 23 percent, while the price of exfoliated vermiculite rose less than 1 percent. The market prices quoted by Engineering and Mining Journal for crude vermiculite from Montana and South Carolina ranged from $18 to $35 per ton, f.o.b. mine. Material from the Republic of South Africa ranged from $29.55 to $40.15 per ton, c.i.f. Atlantic ports.

FOREIGN TRADE

Imports of crude vermiculite from the Republic of South Africa in 1967 were 19 percent higher than in 1966. Crude vermiculite was imported duty free to the United States.

WORLD REVIEW

South Africa, Republic of.—Production of crude vermiculite was 9 percent higher than in 1967. Total exports increased 9 percent over the 1967 tonnage, and value increased 16 percent. The average unit value of crude vermiculite exported from South Africa increased $1.12 per ton.

Table 2.—Free world production of vermiculite by countries

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
Argentina	4,071	1,857	[r] 4,588	[p] 2,641	NA
Brazil	NA	NA	441	240	2,724
India	473	807	551	349	2,588
Kenya	37	24	84	277	308
South Africa, Republic of	111,872	126,911	113,732	111,885	121,427
Tanzania	144	108	177	100	33
United Arab Republic [1]	459	639	NA	NA	NA
United States (sold or used by producers)	226,299	249,352	262,321	254,997	289,997
Total [2]	343,355	379,698	[r] 381,894	370,489	417,077

[r] Revised. [p] Preliminary. NA Not available.

[1] Includes mica.

[2] Total is of listed figures only.

Table 3.—Republic of South Africa: Exports of crude vermiculite by countries

(Short tons)

Destination	1966	1967	1968
Australia	2,549	2,833	NA
Canada	2,565	3,884	
France	8,523	9,418	
Germany, West	11,619	9,296	
Italy	14,123	19,088	
Japan	2,955	4,995	
Netherlands	1,216	1,744	
Spain	2,460	2,942	
Sweden	965	1,340	
United Kingdom	27,277	30,214	
United States	8,432	15,963	
Other countries	3,207	3,903	
Total	85,891	[r] 105,620	115,545
Total value [1]	$1,576,986	[r] $1,980,055	$2,295,439
Average value	$18.36	[r] $18.75	$19.87

[r] Revised. NA Not available.

[1] Converted to U.S. currency at the rate of 1 rand equals $1.3913 (1966), $1,398 (1967), and $1.40 (1968).

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/46

Zinc

By Donald E. Moulds [1]

The free world during 1968 achieved a record production and consumption of zinc. A 2-percent gain in mine production to 4.37 million tons provided the feed materials for a major 11-percent gain in metal production to 3.91 million tons. The free world supply of metal, augmented by a 39,000-ton producer stock drawdown, a 38,000-ton reduction in U.S. Government stocks, and a 72,000-ton net import from communist areas, adequately provided for the 7.6-percent increase in metal consumption and the price of zinc remained stable in all of the free world markets.

The domestic zinc industry experienced a substantial recovery from the 1967 slump in consumption with an increase of 9 percent over the 1967 total but well below that achieved in 1965–66. Mine production, partially curtailed by labor stoppages, declined for the third successive year but smelter production, despite lost output at several plants in the first 4 months due to the continuing strike, increased almost 9 percent and was only 7,500 tons below the 1966 high. The high level of smelter output, augmented by a 38-percent increase in metal imports, failed to meet

---

[1] Physical scientist, Division of Mineral Studies.

Table 1.—Salient zinc statistics

	1964	1965	1966	1967	1968
United States:					
Production:					
Domestic ores, recoverable content short tons	574,858	611,153	572,558	549,413	529,446
Value thousands	$156,308	$178,284	$166,044	$151,562	$142,950
Slab zinc:					
From domestic ores short tons	531,967	551,215	523,580	438,553	499,491
From foreign ores short tons	422,117	443,187	501,486	500,277	521,400
From scrap do	71,596	83,619	83,263	73,505	79,865
Total do	1,025,680	1,078,021	1,108,329	1,012,335	1,100,756
Secondary zinc [1] do	227,713	271,694	277,967	247,254	276,092
Exports of slab zinc do	26,515	5,939	1,406	16,809	33,011
Imports (general):					
Ores (zinc content) do	357,145	428,040	521,320	534,092	546,382
Slab zinc do	118,340	152,990	278,175	222,112	306,540
Stocks, December 31:					
At producer plants do	31,178	28,622	64,798	81,916	63,112
At consumer plants do	108,411	150,763	129,593	102,535	102,438
Consumption:					
Slab zinc do	1,207,268	1,354,092	1,410,197	1,236,808	1,333,699
All classes do	1,535,751	1,742,067	1,806,543	1,591,997	1,728,400
Price, Prime Western, East St. Louis cents per pound	13.57	14.50	14.50	13.85	13.50
World:					
Production:					
Mine short tons	4,440,309	4,750,887	4,960,613	5,330,519	5,471,071
Smelter do	4,070,982	4,352,571	4,498,252	4,549,667	5,017,196
Price: Prime Western, London cents per pound	14.74	14.12	12.75	12.37	11.89

[1] Excludes redistilled slab zinc.

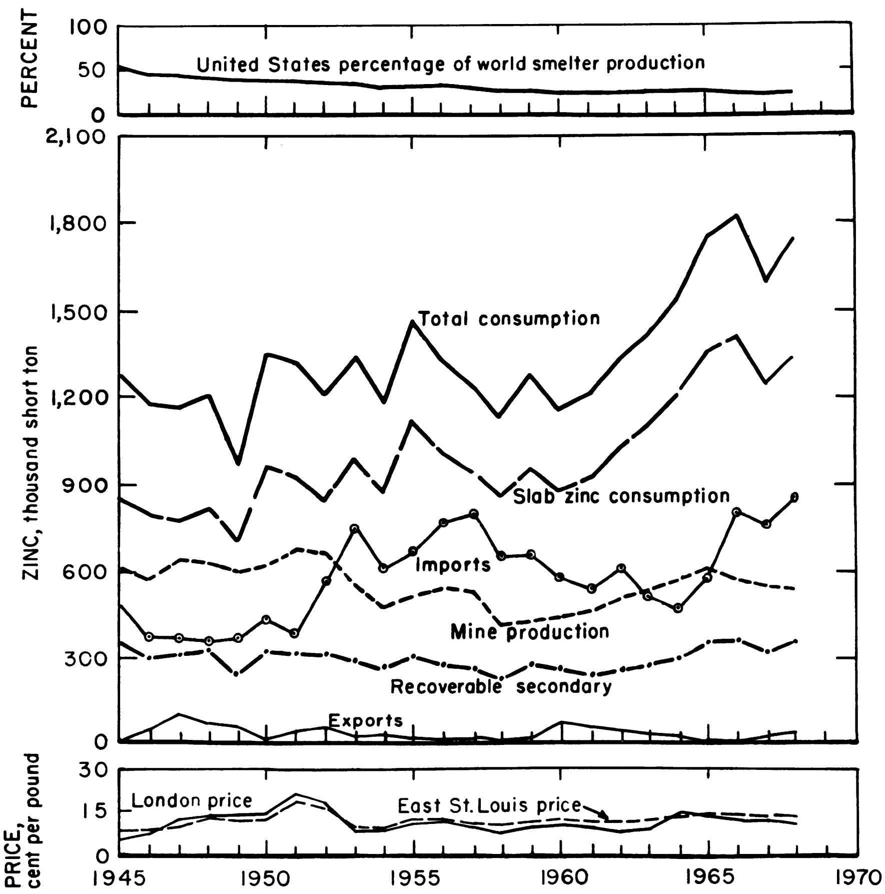

Figure 1.—Trends in the zinc industry in the United States.

demand plus exports by some 65,500 tons as indicated by a 38,000-ton drawdown of Government stockpile inventory and 27,500-ton decrease in producer-consumer stocks during the year. The base price for Prime Western zinc, f.o.b., East St. Louis, however, continued at 13.5 cents per pound throughout the year.

Legislation and Government Programs.—The program under Public Law 89–238, to stabilize mining of lead and zinc by small producers through supplemental payments on eligible production when the market price is less than 14.5 cents per pound, was operative throughout the year and payments totaling $144,661 were made in 1968 on qualified production of 13,151 tons. Since inception of the program in 1962 a total of $2.52 million has been paid on 104,790 tons of combined lead and zinc production to 85 producers in 11 States. Oklahoma leads with about $1 million followed by Idaho, Utah, Kansas, and Montana. This program continues under the present law through 1969.

The General Services Administration continued sales of zinc to industry for domestic consumption under authority of Public Law 89–322 and transfers for Government use under Public Law 89–9. The remaining tonnage authorized for sale at yearend was 39,700 tons for commercial sale and 42,401 tons for Government transfer. Commercial sales commitments in 1968 amounted to 27,181 tons of which the Agency for International Development contracted for 24,763 tons, primarily for export. The actual shipments and decrease in stockpile inventory during the year was 37,516 tons, thus reducing total stocks to 1,160,606 tons, all of which is surplus to present stockpile requirements.

The International Lead and Zinc Study Group held its 12th session in Geneva on November 18–22, preceded by meetings of the various committees on November 13–15. Representatives of 29 member countries attended and reviewed the international supply-demand situation for lead and zinc in 1968 and projections for 1969. The data available at the time of the meeting indicated a reasonable balance in zinc during 1968 in contrast to the surplus supply situation indicated at the 1967 meeting. Projections of increases in mine and metal production in 1969, in excess of a rising consumption requirement, indicated the possibility of a supply surplus. The projected supply was, however, believed overly optimistic and actual results in 1969 were expected to be in reasonable balance with demand. Other topics discussed at the meeting included liberalization of trade, trends in smelter capacity, sources of supply of concentrates, pricing aspects, and coproduct-byproduct relationships in lead-zinc ore production.

DOMESTIC PRODUCTION

MINE PRODUCTION

Recoverable zinc produced at domestic mines totaled 529,400 tons, the third consecutive decrease and approximately 82,000 tons below that produced in 1965. The continuing strike at several of the Western mines plus abnormally low temperatures and snow in the Northern mining areas curtailed production in the first quarter. Missouri production increased as output of the higher zinc content ores of the new lead belt expanded. Tennessee mines provided the largest amount of zinc in 1968 and achieved a new record for the State, exceeding the previous high in 1965. The 25 leading mines produced 76.5 percent of the domestic output compared to 75 percent in 1967. The four largest mines again supplied 25 percent and the first eight mines contributed 41 percent. The States east of the Mississippi River produced 60 percent of the zinc; Western States, 36 percent; and the Kansas-Missouri-Oklahoma area, 4 percent.

The source of zinc in 1968 according to recoverable metal value was as follows: Zinc ores, 69 percent; lead-zinc ores, 19 percent; lead ores, 3 percent; copper-lead-zinc ores, 5 percent; and all other sources, 4 percent. A significant change in 1968 was the 69 percent derived from zinc ores in comparison to 53 percent in 1967. This is a measure of the continuing growth in importance of the Tennessee, New York, New Jersey, and Pennsylvania mines.

Tennessee, the leading State, contributed 23 percent of the domestic production and achieved an increase of almost 10 percent in comparison to 1967 figures. American Zinc Co. operated six mines: Coy, Grasselli, Mascot No. 2, North Friends Station, Young, and Immel. Company production for the period July 1967 to June 1968, was a record 124,520 tons of zinc concentrates from 2.8 million tons of ore mined.[2] The Immel mine had its initial startup on March 1 and production in 1968 placed the mine among the leading 25. The Grasselli mine was permanently closed in February and the North Friends Station mine was also closed during the year. The New Jersey Zinc Co., a subsidiary of Gulf and Western Industries, Inc., operated the Jefferson City and Flat Gap mines and development was proceeding on a third mine. The company announced on January 7, 1969, a major zinc discovery in central Tennessee which should significantly increase the Tennessee zinc reserves. The Zinc Mine Works of United States Steel Corp., and the Copper Hill mine of Tennessee Copper Co., continued to be major zinc producers in 1968.

St. Joseph Lead Co. operated the Balmat and Edwards mines in New York where the combined production totaled 124,500 tons of zinc concentrates. Zinc production from company mines in New York and Missouri accounted for 46 percent of the concentrates used at the firm's Monaco, Pa. zinc smelter. The new mine shaft at the Balmat reached 2,400-foot depth and will bottom at 3,200 feet. A new 4,300-ton-per-day mill was under construction to replace the present 2,200-ton-per-day plant.[3] Output from the Pennsylvania and New Jersey mines operated by The New Jersey Zinc Co. decreased in comparison to that achieved in 1967.

---

[2] American Zinc Co. Annual Report. 1968, p. 6.

Idaho continued to be the leading Western producing State and output increased slightly despite abnormally low temperatures and snowfall that curtailed operations in January and February. The Bunker Hill mine was the leading producer followed by the Star-Morning unit of Hecla Mining Co., and the Page mine of American Smelting and Refining Company. Output at the Star-Morning mine was affected by construction and development of the new No. 4 shaft, expected to be completed at the end of 1969.[4] Extensive exploration and development in depth was continued in the Coeur d'Alene area by the major mining companies during the year.

The Eagle mine of The New Jersey Zinc Co., the Idarado mine of Newmont Mining Co., and the Sunnyside mine operated by Standard Metals Corp., were the leading zinc producers in Colorado. Idarado mine output declined and ore reserves decreased slightly. Resurrection Mining Co., a joint project of Newmont Mining Co. and American Smelting and Refining Company, continued development of a mine at Leadville, Colo., and reserves have been estimated at 2.4 million tons containing 5.13 percent lead and 9.95 percent zinc.[5] Sunnyside mine output was also curtailed and concentrates stockpiled during the strike period.

Ore production at United States Smelting, Refining and Mining Co.'s United States and Lark mines in Utah was adversely affected by a shortage of experienced miners although the grade of ore produced was higher. The Midvale Flotation Mill was idle for several short periods during the early part of the year due to a shortage of ore from shippers affected by the strike. Concentrates were stockpiled until reopening of The Anaconda Company's zinc smelter in April.[6] The output of the Burgin mine of Kennecott Copper Corp. in Utah, was reduced significantly by the long strike settled on March 19 and the delay in reaching full operation due to extensive mine rehabilitation. Construction of a new concentrator was virtually completed and preparation for expanding mine capacity from 500 tons per day to 800 tons was underway. The surface plant for the new Trixie shaft was completed and sinking started in June with a depth of 400 feet achieved by the end of the year.[7]

Production in Arizona, Nevada, and New Mexico was adversely affected by the 8½-month copper mine closure in 1967–68 as illustrated by the decrease of 4,100 tons, compared with 1966 levels, in zinc recovered as a byproduct of copper-base ores.

Missouri was the only Central United States area reporting an increase in output, a reflection of the increased recovery of zinc in the new lead belt. These ores contain approximately 1 ton of zinc for each 5 tons of lead in contrast to the virtually zinc-free ores of the old Southeast lead belt. Activity in the Kansas-Oklahoma area declined with a resulting 36-percent decrease in zinc output. Illinois and Wisconsin output was affected by strikes at some of the mines.

The Pend Oreille mine of Pend Oreille Mines and Metals Co. in Washington, adopted a more selective mining system with a resulting 32-percent decrease in tons of ore milled, a 14-percent decrease in output of zinc concentrates and almost triple the amount of lead concentrates compared with 1967 levels.[8] Concentrate production at the Calhoun mine of American Zinc Co. increased about 38 percent but ore grade at this property has been disappointing.

The outlook for increased domestic zinc mine production in 1969 appears promising with no major labor problem except availability of experienced underground labor. The full year's operation of the expanded Mascot mill and Immel mine in Tennessee, significantly increased production from Missouri as the new mines achieve full capacity, new developments in the Coeur d'Alene area, expansion of mill and mine capacity in Utah and New York, reopening of mines in New Mexico and Washington, and full-scale operation of copper mines all indicate a continuing upward output of recoverable zinc in ore.

---

[3] St. Joseph Lead Co. Annual Report. 1968, p. 9.

[4] Hecla Mining Co. Annual Report. 1968, p. 9.

[5] Newmont Mining Co. Annual Report. 1968, p. 18.

[6] United States Smelting, Refining and Mining Co. Annual Report. 1968, p. 11.

[7] Kennecott Copper Corp. Annual Report. 1968, p. 12.

[8] Pend Oreille Mines and Metals Co. Annual Report. 1968, p. 11.

SMELTER AND REFINERY PRODUCTION

Domestic smelter production of slab zinc increased 8 percent. The continuing labor strike initiated in mid-1967 at the smelters operated by American Smelting and Refining Company and The Anaconda Company was terminated in April and, with an accumulation of concentrates available, capacity operation was quickly reestablished. Production, averaging 73,400 tons of slab zinc for the first quarter, built up to a high of 101,900 tons in May and averaged 91,700 tons for the year. Shipments, averaging 80,500 tons for the first quarter, exceeded 100,000 in May, October, and November and averaged 91,700 tons for the year, indicating a drawdown of 1,400 tons per month.

Domestic slab zinc annual capacity was increased over 50,000 tons in 1968 with completion of expansion projects for metal processing and refining at the Monsanto plant of American Zinc Co., The Bunker Hill Co. electrolytic plant at Kellogg, Idaho, the New Jersey Zinc Co. plant at Depue, Ill., and the National Zinc Co. plant at Bartlesville, Okla. The Henryretta, Okla. horizontal retort plant of The Eagle-Picher Industries, Inc., was closed at yearend and company concentrates will be processed at the expanded plant of National Zinc Co. in 1969.

Slab Zinc.—Primary slab zinc plants were operated by 10 companies at 14 locations in 1968 with an annual capacity of over 1.3 million tons and 12 companies operated secondary slab zinc plants at 13 locations with a 55,900-ton total annual capacity. Production of 1.1 million tons of zinc in 1968 was derived from domestic ores, 46 percent; foreign ores, 47 percent; and redistilled secondary, 7 percent. Electrolytic zinc comprised 36 percent of the total; distilled zinc, 57 percent; and redistilled at primary and secondary plants, 7 percent. Special High Grade represented 41 percent of the total slab zinc produced in comparison to 43 percent in 1967. Prime Western, the basic grade, amounted to 36 percent and all other grades, 23 percent. The most significant change in 1968 was the increase in intermediate grade and the decrease in brass special in relation to that during prior years.

The Zinc Smelting Division of St. Joseph Lead Co., increased production 9 percent to 206,200 tons at its Monaca, Pa., plant.[9] American Smelting and Refining Company produced 124,000 tons of zinc, a 4-percent decrease in relation to the strike-curtailed 1967 output and well below the 155,000-ton output in the preceding year.[10] American Zinc Co. produced 124,300 tons of slab zinc at the Dumas, Tex., retort plant and Monsanto, Ill., electrolytic plant. Production was voluntarily curtailed at the Dumas plant in the first half of the year and the electrolytic plant encountered startup difficulties in the newly installed roasting and casting facilities, although calendar 1968 production slightly exceeded that during 1967.[11] The Blackwell, Okla., plant of American Metal Climax, Inc., produced 90,000 tons of slab zinc, slightly higher than the 1967 output.[12] The Anaconda Company resumed operations at its Anaconda and Great Falls, Mont., electrolytic plants on April 1 after settlement of the strike and operated at 75-percent capacity for the remainder of the year. Output was 148,443 tons of zinc of which only 1,300 tons came from company mines. Approximately 58 percent of the output was from material processed on toll.[13] National Zinc Co. expanded its horizontal retort plant at Bartlesville, Okla., during the year and will process zinc concentrates from The Eagle-Picher Industries Inc., mines in 1969.

Slag-Fuming Plants.—Processing of lead smelter slags to recover the contained 7 to 13 percent zinc and small amounts of lead was continued at five plants—American Smelting and Refining Company at El Paso, Tex., and Selby, Calif.; The Anaconda Company at East Helena, Mont.; The Bunker Hill Co. at Kellogg, Idaho; and International Smelting & Refining Co. at Tooele, Utah. Material processed during the year consisted of 572,400 tons of hot slag from smelters, 36,400 tons of old slag and 3,900 tons of crude ore, all of which yielded 113,600 tons of oxide fume containing 72,900 tons of recoverable zinc.

---

[9] St. Joseph Lead Co. Annual Report. 1968, p. 10.

[10] American Smelting and Refining Company. Annual Report. 1968.

[11] American Zinc Co. Annual Report. 1968, p. 4.

[12] American Metal Climax, Inc. Annual Report. 1968, p. 13.

[13] The Anaconda Company. Annual Report. 1968, pp. 9, 30.

Secondary Zinc Smelters.—Zinc recovered from reprocessing new and old scrap amounted to 354,700 tons compared to 319,800 tons in 1967. New scrap, principally zinc-base and copper-base alloys from manufacturers and drosses from molten galvanizing and die casting pots, contributed 274,900 tons. Old scrap, consisting of die castings, engravers' plate and other obsolete or wornout objects, amounted to 79,800 tons. The zinc was recovered in alloys, 53 percent, principally brass and bronze; in metal, 34 percent; and in chemical products, 13 percent.

Byproduct Sulfuric Acid.—Gases produced in roasting zinc sulfide concentrates preparatory to retorting or electrolytic reduction to zinc metal contain significant quantities of sulfur dioxide which are collected and processed to sulfuric acid. At several plants elemental sulfur is also burned to supplement output. Production of acid in 1968 was 990,000 tons compared with 900,200 tons in 1967.

Zinc Dust.—Production of zinc dust resumed the upward trend of recent years. In 1958 production amounted to 26,500 tons valued at $7.3 million in comparison to the 1968 output of 61,600 tons valued at $22 million. The statistics include only commercial grades ranging in zinc content from 95.0 to 99.6 percent and averaged 98.53 percent during the year.

CONSUMPTION AND USES

Consumption of slab zinc amounted to 1.33 million tons, 8 percent above the 1967 total but lower than that used in 1965–66. The increase in requirements occurred in essentially all of the industrial uses with the exception of a few categories in galvanizing.

Zinc-base alloy requirements represented 42 percent of the total slab in comparison to 43 percent in 1967 and the record 47 percent in 1965. Galvanizing requirements were 36 percent compared with the previous year's 37 percent. Noteworthy was the continued uptrend in galvanizing of structural shapes indicating the installation and use of large hot-dip galvanizing pots capable of galvanizing assembled structural components. Consumption in brass products was 12 percent, despite the strike at several brass mills in the first quarter, compared with the 11 percent required in 1967, a year also beset by labor strikes. Rolled zinc requirements for slab zinc advanced 8 percent to 48,900 tons although well below the 52,600 tons used in 1966. Use in zinc oxide has steadily climbed from 13,300 tons in 1958 to the 34,900 tons used in 1968.

Consumption of slab zinc by grades was as follows: Special High grade, 51 percent; Prime Western, 28 percent; Brass Special, 10 percent; Intermediate, 9 percent; and High grade and remelt, 2 percent. Galvanizing used mainly Prime Western although higher purity was required in the high-speed, continuous lines. Special High grade is required in high-speed die casting alloys with lower grades used in sand and slush casting alloys. Zinc used as an additive in copper-base alloys ranges through the various grades although Brass Special and Intermediate are relative minor commercial grades.

Rolling mills used 48,900 tons of slab zinc and produced 47,500 tons of salable products, mainly as strip and foil. Imports of rolled products approximated 800 tons in comparison to exports of 3,000 tons and the apparent domestic consumption of 45,300 tons was 10 percent higher than in 1967. In addition, rolling mills remelted and rerolled 21,900 tons of scrap originating in manufacturing of end products at the plants.

Illinois was the leading State in total slab zinc consumption while Ohio led in galvanizing, Michigan in diecasting, and Connecticut in use in brass. Five States—Illinois, Michigan, Indiana, Pennsylvania, and New York—each consumed over 100,000 tons of slab zinc and combined accounted for almost 57 percent of the domestic total.

ZINC PIGMENTS AND COMPOUNDS

Production.—Output of zinc pigments and compounds, excluding lithopone, increased 13 percent to 336,100 tons, well above the recent high of 325,200 tons achieved in 1966. Shipments of zinc oxide and zinc sulfide exceeded production, and totaled 339,000 tons in 1968 compared with 291,800 tons in 1967 and 313,400 tons in 1966.

Zinc oxide was processed from domestic and foreign ores, slab zinc, secondary materials, and residues. Lead-free zinc oxide produced from ores and residues by the American Process contributed 63 percent of the total. The French Process using slab zinc accounted for 25 percent and 12 percent was derived by various other oxidation processes using residues and secondary materials. Production of zinc oxide and zinc sulfate required an equivalent of 108,400 tons of zinc in ore of which domestic sources provided 67 percent. The 66,800 tons of zinc in ores used directly in these compounds represents 12.6 percent of the domestic output of recoverable zinc in ore.

Lithopone, a coprecipitate of zinc sulfide and barium sulfate, primarily used as a white pigment in paints, fabrics, paper, and rubber, was produced but data cannot be published without disclosing individual company confidential data.

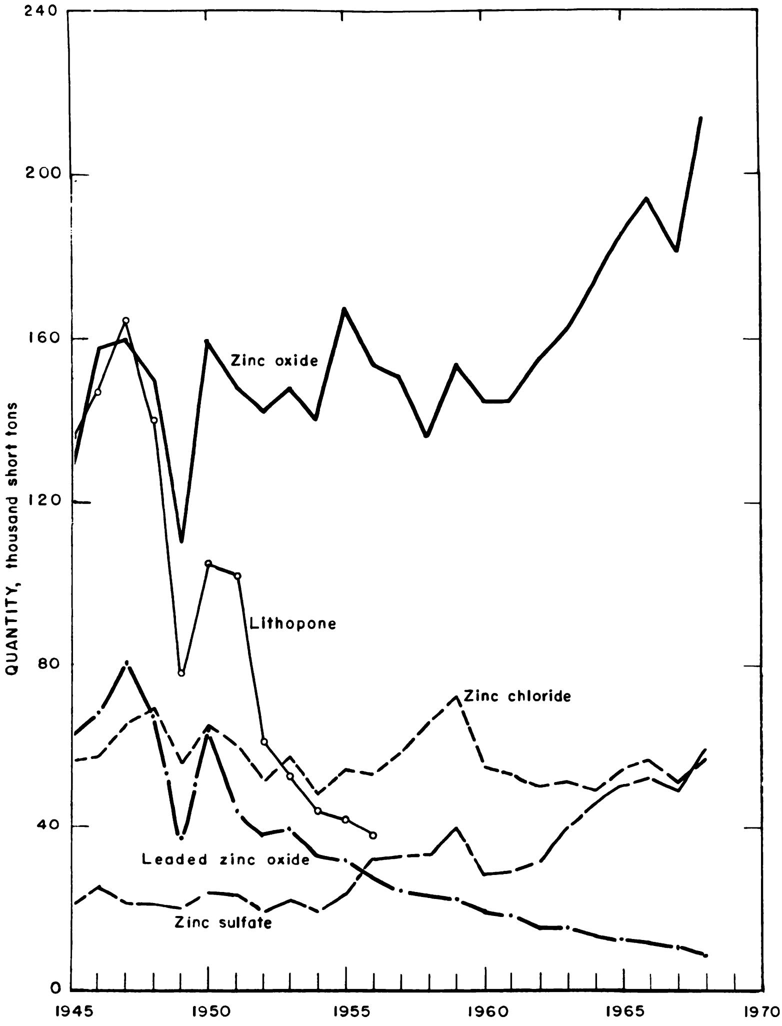

Figure 2.—Trends in shipments of zinc pigments.

Consumption and Uses.—The leading use of zinc oxide was in rubber which required 52 percent of tonnage shipped. Consumption in rubber has increased significantly in the last decade, from 68,200 tons in 1958 to 111,800 tons in 1968. A small increase in paints reversed the downtrend in this area and ceramics was, also, slightly higher. Use in chemicals has doubled since 1965 and photocopying since 1966. Agriculture is rapidly becoming a major consumer of oxide as a plant and animal feed supplement.

Leaded zinc oxide continued to decrease significantly as a paint pigment although increasing slightly in other areas, especially in the low lead grades. Manufacture of zinc chloride and allied chloride compounds consumed 14,100 tons of zinc for industrial use in batteries, solder flux, fungicides, and vulcanizing. The chief uses for 54,100 tons, dry weight, of zinc sulfate shipments, a record amount, were in rayon and in agriculture.

Prices.—The stability of the zinc price of 13.5 cents per pound throughout the year was reflected in the unchanged price of zinc pigments and compounds during the year. Lead-free zinc oxide prices in carload lots, freight allowed, in cents per pound, were as follows: 15.25 for American Process, 17.50 for French Process, Green Seal grade, 17.75 for French Process, White Seal grade. Leaded zinc oxide was quoted at 15.75 for the 35-percent grade and 16.50 for the 50-percent grade.

Zinc sulfate (monohydrate, 36 percent) in carload lots, was quoted at 9.50 cents per pound throughout the year. Zinc chloride 50° Baumé, in tank cars, was quoted at 5.80 cents per pound until October 1 when increased to 6.20 cents.

Foreign Trade.—Exports of zinc oxide were distributed among 40 countries with Belgium-Luxembourg, Canada, and Colombia the three largest recipients. Lithopone was shipped to 25 countries with Canada the major importer, followed by South Vietnam.

Imports of zinc pigments and compounds increased almost 10 percent in tonnage and 22 percent in value. Zinc oxide imports of 15,600 tons represented almost 6 percent of the new supply as indicated by domestic shipments plus imports. Mexico was the largest supplier of zinc oxide followed by the Netherlands, United Kingdom, West Germany, and Canada. The leading supplier of zinc sulfide was West Germany who also supplied most of the lithopone. Zinc chloride was largely supplied by Belgium-Luxembourg and West Germany and Mexico was the predominant source of zinc sulfate.

STOCKS

Producer Stocks.—Stocks of slab zinc at producer plants amounted to 81,900 tons at the beginning of the year and after a drawdown during the first quarter to about 63,000 tons at the end of March gradually built up to 85,000 tons at the end of August and then declined to 63,100 tons at yearend. Producer stocks, other than at plants, as reported by the Zinc Institute, ranged from a low of 7,200 tons in April to 15,500 tons at yearend.

Consumer Stocks.—Slab zinc stocks held by consumers opened the year at 102,500 tons but were reduced to about 74,000 tons at the end of November. A drop in consumption, increased metal imports, and continued high-level domestic production and shipment in December, however, increased stocks to 102,400 tons, only 100 tons below that existing at the start of the year.

PRICES

The price of slab zinc in world markets was steady throughout the year after a downward adjustment in 1967. The quoted price of Prime Western grade, East St. Louis market, after a decrease from 14.5 cents per pound to 13.5 cents, effective June 19, 1967, continued unchanged throughout 1968. The European producer price was also steady at 12.25 cents (U.S. equivalent). The London Metal Exchange (LME) monthly average range was narrow with a low of 11.7 cents in March and April and a high of 12.2 cents in August. The closing LME settlement price on December 29, 1968, was 12.01 cents per pound.

FOREIGN TRADE

Exports of slab zinc increased to 33,000 tons of which India received 98 percent, again reflecting deliveries of Government stockpile zinc in connection with contracts through the U.S. Agency for International Development. Export of rolled zinc items —sheets, plates, strip, etc.—continued to decline with shipment of 3,000 tons of which Canada imported 65 percent. Export of scrap and dross increased to 2,300 tons zinc content, and a major increase to a total of 15,000 tons in export of miscellaneous semifabricated zinc items was reported by the Bureau of the Census.

General imports amounted to 546,400 tons of zinc in ores and 306,500 tons of metal. The import of ore was believed to be a record high surpassing the 539,000 tons received in 1943. The 306,500 tons of zinc metal imported was also a record surpassing the 269,000 tons received in 1957 just prior to imposition of import quotas in 1958.

Canada and Mexico contributed 83 percent of the total ore and Canada, Peru, and Japan provided 71 percent of the metal.

Imports of zinc fume for consumption, all from Mexico, amounted to 18,509 tons (zinc content). A large part of the fume was previously imported under bond and entered with payment of duty in 1968.

Lead and zinc were excluded in the Kennedy Round of tariff discussions under the General Agreement on Tariff and Trade and duties on unmanufactured zinc and zinc containing materials remained unchanged and were as follows: Slab zinc, 0.7 cent per pound; zinc ores, concentrates, and fume, 0.67 cent per pound (on zinc content less certain allowable deductions for processing losses); zinc scrap, 0.75 cent per pound; and zinc dust, 0.7 cent per pound.

WORLD REVIEW

Statistical summaries of world zinc production and consumption compiled by the Bureau of Mines, American Bureau of Metal Statistics (ABMS), and the International Lead and Zinc Study Group, vary in reporting base, sources, and scope of estimating. Free world mine production thus ranges from the 4.17 million ton total of ABMS through the 4.37 million ton total of the Bureau of Mines to the 4.39 million tons of the Lead and Zinc Study Group. The addition of the Bureau of Mines estimate of 1.1 million tons mined in communist areas, excluding Yugoslavia, results in a world total of 5.47 million tons, an increase of almost 2 percent over the 1967 total. Smelter output also varies widely with the Bureau of Mines reporting insofar as possible, primary metal while the Lead and Zinc Study Group reports slab zinc output from both primary and secondary sources. Free world smelter output of zinc thus ranges from 3.91 million tons reported by the Bureau of Mines through 3.96 million tons reported by ABMS to the 4.03-million-ton total of the Lead and Zinc Study Group. In addition, the communist areas, excluding Yugoslavia, are estimated to have produced 1.1 million tons, thus giving a world smelter output of some 5 million tons in 1968, an 11-percent increase. The Lead and Zinc Study Group reports metal production and metal consumption on the same basis and the free world consumption of 4.05 million tons of zinc compared with 4.03 million tons produced indicates a shortage of 20,000 tons in new metal. This is supported by the producer stock drawdown of 35,600 tons during the year.

Mine production expanded significantly in Finland, Ireland, Italy, Spain, and Yugoslavia, and the overall increase for Europe approximated 75,000 tons in ore. European metal production also showed a major increase of 195,000. African output increased due to the larger output in Zambia. The increase in mine output in Canada and Peru was countered by the decrease in the United States to provide a net increase of only 4,000 tons in North and South America. Smelter production increased, however, in all of the metal producing countries. Mine production in Asia increased and, although Japanese mine output was only slightly higher, smelter output in Japan continued the upward trend with a 17-percent increase based mainly on imported ore. Australia increased mine and smelter production at approximately the same rate.

Algeria.—Algerian zinc ore production, which declined drastically in 1966–67, due to nationalization and subsequent shutdown of the El Abed mine near the Moroccan border, increased in 1968 with resumption of operations. The Government announced plans to construct a concentrator of 100,000-ton-per-year capacity at the El Abed mine and also equip the Kerzet-Yousof and Kef Oum Thebaul mines with concentrators. The development plan also included a zinc electrolytic plant of 10,000-ton capacity at Ghazouch.

Argentina.—Cía. Minera Aguilar, S.A., a wholly owned subsidiary of St. Joseph Lead Co., proceeded with expansion of its mine and mill in Jujuy Province and despite interruptions due to the installation of new equipment, mined and milled approximately the same tonnage as in 1967. Zinc concentrate production was 51,100 tons.

Compañía Sulfacid, S.A., an Argentine corporation with a plant at Rosario and 50-percent owned by Minera Aguilar, proceeded with plans to increase roaster and electrolytic tank capacity and eventually double the plant capacity. Compañía Metalúrgica Austral's zinc smelter, located at Comodoro Rivadavia, also partially owned by Minera Aguilar, continued operations at a satisfactory level in 1968.[14]

Australia.—Mine production was running at a rate of 415,000 tons at the end of the first quarter but onset of labor difficulties at Broken Hill in mid-May lowered production drastically until normal operations were resumed at the end of August. Commissioning of the new K–57 shaft at Mount Isa Mines Ltd. released the U–52 shaft for production of lead-zinc ore and while total ore production decreased slightly during fiscal 1967–68, production of zinc increased from 39,300 tons to 54,900 tons.[15] The new slag fuming plant and electrolytic zinc refinery of The Broken Hill Associated Smelters Pty. Ltd., at Port Pirie, came on stream at the end of 1967 with an annual capacity of 60,000 tons of refined zinc. Plans to treat other dumps of zinc-bearing residues were announced independently in November by Mount Isa Mines Ltd., and E. Z. Industries Ltd. A continuation of power restrictions due to water shortages in Tasmania curtailed production at the Risdon Works of E. Z. Industries Ltd. until June and production in fiscal 1968 decreased from 143,900 tons to 129,800 tons.

Austria.—The one lead-zinc mine operated by Bleiberger Bergwerksunion, A.G., produced about 9,000 tons of recoverable zinc. The company's electrolytic plant produced 15,700 tons of zinc metal with additional concentrates obtained from the nearby Italian mine of Miniere Cave del Predil, S.A. Expansion of the Austrian mine is underway with a planned increase of 70 percent in output.

Canada.—Mine production of zinc established a new record for the seventh consecutive year and as the world's leading zinc producer, the 1.27 million tons represented 23 percent of the world total. Although the four Canadian primary smelting plants operated below rated capacity, the 427,000 tons was 5 percent above the 1967 output and rates Canada as the fourth largest zinc metal producer in the world. Exports of zinc in concentrates also increased by some 13 percent.

Cominco, Ltd., continued to be the dominant zinc producer in Canada with large mines operating in British Columbia and Northwest Territories, and the world's largest electrolytic zinc plant at Trail, British Columbia. Output of refined zinc was 210,000 tons compared with 202,000 tons in 1967. Ore purchased from Pine Point Mines Ltd. (69-percent owned by Cominco, Ltd.) provided 50 percent of the lead-zinc metal produced at Trial, British Columbia. The totally-owned Sullivan and Bluebell mines proved 41 percent and the remainder came from slags, residues, and ore purchased from other mines. High-grade ore shipments from Pine Point accounted for 47 percent of the total sales revenue in 1968 and were terminated in mid-December with exhaustion of presently available high-grade ore reserves. The ore body acquired from Pyramid Mining Co. Ltd., adjoining the Pine Point ore body, was prepared for production on schedule at the end of 1968 and the 3,000-ton-per-day concentrator addition to the Pine Point mill was completed and in startup testing in December.[16]

Ecstall Mining, Ltd., a subsidiary of Texas Gulf Sulphur Co., completed the first full year of operation at the Kidd

---

[14] St. Joseph Lead Co. Annual Report. 1968, pp. 13–16.

[15] American Smelting and Refining Company. Annual Report. 1968, pp. 5–6.

[16] Cominco, Ltd. Annual Report. 1968, pp. 8–11.

Creek mine near Timmins, Ontario, and milled 3.6 million tons of ore to produce 562,400 tons of 52-percent zinc concentrates for sale to smelters in the United States, Europe, and Japan.[17]

Hudson Bay Mining and Smelting Co., Ltd., operated the Flin Flon, Chisel Lake and Schist Lake zinc-copper mines and produced 131,300 tons of 48-percent zinc concentrates.

Brunswick Mining and Smelting Corp., Ltd., operated the No. 12 mine and No. 6 mine throughout the year. Ore milled from No. 12 amounted to 1.7 million tons averaging 9 percent zinc and produced 221,100 tons of zinc concentrates. Reserves are estimated at 60.8 million tons of ore. The No. 6 mine output was 867,000 tons averaging 6 percent zinc. Reserves were estimated at 17.8 million tons. The initial plan of producing low-grade, zinc-lead concentrate for the Imperial Smelting Furnace feed was modified to a higher grade to improve smelter operation. The East Coast Smelting and Chemical Company, Ltd., operated the Imperial Smelting plant at Belledune, New Brunswick, throughout the year and produced 25,160 tons of slab zinc.[18]

Plant construction and pit preparation continued at the property of Anvil Mining Corp., Ltd., 60-percent owned by Cyprus Mines Corp. and 40-percent by Dynasty Exploration, Ltd. Three million cubic yards of waste have been removed from the open pit. Approximately 50 percent of preproduction stripping has been completed and development of a townsite was started in late 1968. The road link from Whitehorse to the mine was completed during the year and development of power facilities were underway. Production is expected late in 1969 with an annual rate of 240,000 tons of zinc concentrates expected at full-scale operations.[19]

Finland.—The state controlled mining firm Outokumpu Oy increased ore production 13 percent in 1968 compared with the previous year's level and zinc concentrates amounted to 132,600 tons for the year. Construction of a zinc smelting plant at Kokkola with an annual capacity of 90,000 metric tons of metal is underway and scheduled for completion in 1970.

India.—Smelter production increased from 3,400 tons to 22,800 tons with the first full year of operation of the Cominco-Binani Zinc Ltd. smelter, a joint venture of Metal Corporation of India, Ltd., and Cominco, Ltd. (Canada), commissioned in April 1967, and also, the Government-owned Hindustan Zinc Ltd. in Rajasthan commissioned in November 1967.

Iran.—The new mill operated by Rio Tinto-Zinc Corp. Ltd., at the Kouchke mine, reached designed capacity of 600 tons per day and production of 50,000 tons of mixed lead-zinc sulfide concentrate per year will be exported to European smelters. The mine has developed 5 million tons of 16-percent combined lead-zinc ore and is owned by Rio Tinto, Société Miniere et Métallurgíque de Peñarroya, and the Iranian company, Simiran.

Ireland.—The Republic of Ireland in less than 3 years has become a major lead-zinc producer. The Tynagh mine in Galway which began production in December 1965, produced about 18,000 tons of zinc and the Mogul of Ireland operation in Tipperary began milling ore in May 1968. Concentrates are smelted on the Continent but studies are underway relative to establishment of a lead-zinc smelter-refinery complex in Ireland.

Japan.—The new Imperial Smelting Furnace of Hachinohe Smelting Co., owned by six Japanese metal producing companies, approached completion at the end of 1968. This smelter, with an annual capacity of 60,000 tons of zinc, will increase total capacity in 1969 to about 1.6 million tons, divided among nine companies.

Peru.—Mitsui Mining and Smelting Co. Ltd. of Japan began operations at the Huanzala mine with an expected monthly output of 5,000 tons of flotation concentrates. Reserves were estimated at 2.2 million tons containing 13 percent zinc and 7 percent lead. Companía Minerales Santander Inc., a subsidiary of St. Joseph Lead Co., completed the 700-foot shaft and related facilities during the year and transferred ore production from the open pit to the underground mine. Production in 1968 was 69,200 tons of zinc concentrates.[20] The output of zinc by Cerro de Pasco Corp., a subsidiary of Cerro Corp., was essentially the same as in 1967. Refined zinc, however, increased to 72,600 tons from 68,000 tons with a corresponding decrease in export of zinc in concentrates. Zinc from purchased ores also decreased from 5 percent of the total to 4 percent in 1968.[21]

---

[17] Texas Gulf Sulphur Co. Annual Report. 1968, p. 8.

[18] Brunswick Mining and Smelting Corp., Ltd. Annual Report. 1968, pp. 6–9.

[19] Cyprus Mines Corp. Annual Report. 1968, p. 22.

[20] St. Joseph Lead Co. Annual Report. 1968, p. 16.

Poland.—The Imperial Smelting Furnace at the integrated zinc-lead works of Zjednoczenie Gorniczo-Hutnicze Metali Nuzelaznych at Miasteczko, in Upper Silesia, was placed in operation in early November. A new lead-zinc mine at Olkusz near Krakon, was placed in operation in December and construction continued at other mines in this district.

TECHNOLOGY

A comprehensive coverage of zinc technology as reported in various scientific and technical publications was included in the joint monthly publication of the Zinc Development Association (London), and Zinc Institute Inc., New York, and presented as a list in the annual index. This publication will be sent, free of charge, upon request addressed to Zinc Institute Inc., 292 Madison Ave., New York, N.Y. 10017.

The International Lead-Zinc Research Organization (ILZRO) sponsored numerous projects to develop basic information on specific applications of zinc. Reports relating to these projects are published in the ILZRO Research Digest and are available, also, upon request from the Zinc Institute, Inc.

The results of Bureau of Mines research on analytical methods for zinc minerals[22] and on rolling of zinc alloys were published.[23]

The U.S. Geology Survey published several reports relating to area geology of zinc deposits and zinc resources.[24]

---

[21] Cerro Corp. Annual Report. 1968, p. 4.

[22] Gabler, Robert C. Jr., and Maurice J. Peterson. A Comparison of Five Spectrochemical Methods for the Analyses of High Purity Zinc. J. Appl. Spectroscopy, v. 22, No. 1, January–February 1968, pp. 19–23.

Powell. H. E., and Lee N. Ballard. Magnetic Susceptibility of Copper-, Lead-, and Zinc-Bearing Minerals. BuMines Inf. Circ. 8383, 1968, 11 pp.

[23] Neumeier, L. A., J. T. Dunham, and P. G. Barnard. Evaluation of Rolling Slabs of Zinc-Copper-Titanium Alloys Cast Under Semicontinuous Conditions. BuMines Rept. of Inv. 7089, 1968, 24 pp.

[24] Jolly, J. L., and A. V. Heyl. Mercury and Other Trace Elements in Sphalerite and Wallrocks From Central Kentucky, Tennessee, and Appalachian Zinc Districts. U.S. Geol. Survey Bull. 1252–F, 1968, pp. F1–F29.

Reed, B. L., and R. L. Elliott. Lead, Zinc, and Silver Deposits at Bowser Creek, McGrath A–2 Quadrangle, Alaska. U.S. Geol. Survey Circ. 559, 1968, 17 pp.

Segerstrom, Kenneth. Geochemical Prospecting for Copper, Lead, and Zinc in the West-Central Part of the Negaunee Quadrangle, Marquette County, Mich. U.S. Geol. Survey Map I–559, 1968.

Sharp, W. N., and J. L. Gualtieri. Lead, Copper, Molybdenum, and Zinc Geochemical Anomalies South of the Summitville District, Rio Grande County, Colo. U.S. Geol. Survey Circ. 557, 1968, 7 pp.

Table 2.—Mine production of recoverable zinc in the United States, by States

(Short tons)

State	1964	1965	1966	1967	1968
Arizona	24,690	21,757	15,985	14,330	5,441
California	143	225	335	441	3,525
Colorado	53,682	53,870	54,822	52,442	50,258
Idaho	59,298	58,034	60,997	56,528	57,248
Illinois	13,800	18,314	15,192	20,416	18,182
Kansas	4,665	6,508	4,769	4,765	3,012
Kentucky	2,063	5,654	6,586	6,317	[1] 9,702
Maine	---------	---------	---------	---------	(1)
Missouri	1,501	4,312	3,968	7,430	12,301
Montana	29,059	33,786	29,120	3,341	3,778
Nevada	582	3,858	5,827	3,035	2,104
New Jersey	32,926	38,297	25,237	26,041	25,668
New Mexico	29,833	36,460	29,296	21,380	18,686
New York	60,754	69,880	73,454	70,555	66,194
Oklahoma	12,159	12,715	11,237	10,670	6,921
Oregon	W	W	---------	---------	---------
Pennsylvania	30,754	27,635	28,080	35,067	30,382
Tennessee	115,943	122,387	103,117	113,065	124,039
Utah	31,428	27,747	37,323	34,251	33,153
Virginia	21,004	20,491	17,666	18,846	19,257
Washington	24,296	22,230	24,772	21,540	13,884
Wisconsin	26,278	26,993	24,775	28,953	25,711
Total	574,858	611,153	572,558	549,413	529,446

W Withheld to avoid disclosing individual company confidential data; excluded from total.

[1] Production of Kentucky and Maine combined to avoid disclosing individual company confidential data.

Table 3.—Mine production of recoverable zinc in the United States, by months

(Short tons)

Month	1967	1968	Month	1967	1968
January	43,173	42,894	August	48,821	46,679
February	43,501	41,985	September	43,283	45,081
March	50,817	41,667	October	43,779	47,038
April	49,528	43,723	November	41,814	44,178
May	50,493	45,297	December	41,537	43,254
June	47,967	44,664			
July	44,700	42,986	Total	549,413	529,446

Table 4.—Twenty-five leading zinc-producing mines in the United States in 1968, in order of output

Rank	Mine	County and State	Operator	Source of zinc
1	Balmat	St. Lawrence, N.Y.	St. Joseph Lead Co	Zinc ore.
2	Friedensville	Lehigh, Pa	The New Jersey Zinc Co	Do.
3	Sterling Hill	Sussex, N.J	do	Do.
4	Young	Jefferson, Tenn	American Zinc Co	Do.
5	Eagle	Eagle, Colo	The New Jersey Zinc Co	Zinc ore, silver ore.
6	Bunker Hill	Shoshone, Idaho	The Bunker Hill Co	Lead-zinc, zinc ores, silver tailings.
7	Zinc Mine Works	Jefferson, Tenn	United States Steel Corp	Zinc ore.
8	Austinville and Ivanhoe.	Wythe, Va	The New Jersey Zinc Co	Do.
9	New Market	Jefferson, Tenn	New Market Zinc Co	Do.
10	Edwards	St. Lawrence, N.Y.	St. Joseph Lead Co	Do.
11	Jefferson City	Jefferson, Tenn	The New Jersey Zinc Co	Do.
12	Star-Morning	Shoshone, Idaho	Hecla Mining Co	Lead-zinc ore.
13	Idarado	Ouray and San Miguel, Colo.	Idarado Mining Co	Copper-lead-zinc ore.
14	U.S. and Lark	Salt Lake, Utah	United States Smelting Refining and Mining Co.	Lead-zinc ore.
15	Mascot No. 2	Knox, Tenn	American Zinc Co	Zinc ore.
16	Flat Gap	Hancock, Tenn	The New Jersey Zinc Co	Do.
17	Shullsburg	Lafayette, Wis	Eagle-Picher Industries, Inc	Do.
18	Burgin	Utah, Utah	Kennecott Copper Corp	Lead-zinc ore.
19	Calhoun	Stevens, Wash	American Zinc Co	Zinc ore.
20	Copperhill	Polk, Tenn	Tennessee Copper Co	Copper-zinc ore.
21	Immel	Knox, Tenn	American Zinc Co	Zinc ore.
22	Page	Shoshone, Idaho	American Smelting and Refining Company.	Lead-zinc ore.
23	Elmo No. 1	Grant, Wis	The New Jersey Zinc Co	Zinc ore.
24	Fletcher	Reynolds, Mo	St. Joseph Lead Co	Lead ore.
25	Deardorff Group	Hardin and Pope, Ill	Ozark-Mahoning Co	Fluorspar ore, zinc ore.

Table 5.—Primary and redistilled secondary slab zinc produced in the United States

(Short tons)

	1964	1965	1966	1967	1968
Primary:					
From domestic ores	531,967	551,215	523,580	438,553	499,491
From foreign ores	422,117	443,187	501,486	500,277	521,400
Total	954,084	994,402	1,025,066	938,830	1,020,891
Redistilled secondary	71,596	83,619	83,263	73,505	79,865
Total (excludes zinc recovered by remelting)	1,025,680	1,078,021	1,108,329	1,012,335	1,100,756

Table 6.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by methods of reduction

(Short tons)

Method of reduction	1964	1965	1966	1967	1968
Electrolytic primary	389,383	408,128	433,576	371,267	398,265
Distilled	564,701	586,274	591,490	567,563	622,626
Redistilled secondary:					
At primary smelters	57,546	70,306	71,560	58,341	67,101
At secondary smelters	14,050	13,313	11,703	15,164	12,764
Total	1,025,680	1,078,021	1,108,329	1,012,335	1,100,756

Table 7.—Distilled and electrolytic zinc, primary and secondary, produced in the United States, by grades

(Short tons)

Grade	1964	1965	1966	1967	1968
Special High Grade	468,748	479,736	452,722	436,849	449,659
High Grade	112,056	112,451	139,814	92,956	117,224
Intermediate	19,050	17,985	23,555	26,522	56,686
Brass Special	81,034	86,695	103,184	91,079	75,840
Select	326	309	----------	----------	----------
Prime Western	344,466	380,845	389,054	364,929	401,347
Total	1,025,680	1,078,021	1,108,329	1,012,335	1,100,756

Table 8.—Primary slab zinc produced in the United States, by States where smelted

(Short tons)

State	1964	1965	1966	1967	1968
Idaho	91,761	91,000	90,983	92,134	102,946
Illinois	114,866	114,131	96,809	115,659	119,657
Montana	125,334	143,927	174,821	111,834	142,929
Oklahoma	150,356	154,187	165,162	163,826	172,174
Pennsylvania and West Virginia	262,981	278,870	291,403	271,192	302,884
Texas	208,786	212,287	205,888	184,185	180,301
Total	954,084	994,402	1,025,066	938,830	1,020,891

Table 9.—Primary slab zinc plants by group capacity in the United States in 1968

Type of plant	Plant location	Slab zinc capacity (short tons)
Electrolytic plants:		
American Smelting and Refining Company	Corpus Christi, Tex	538,000
American Zinc Co	Sauget, Ill	
The Anaconda Company	Anaconda, Mont	
Do	Great Falls, Mont	
The Bunker Hill Co	Kellogg, Idaho	
Horizontal-retort plants:		
American Smelting and Refining Company	Amarillo, Tex	780,200
American Zinc Co	Dumas, Tex	
Blackwell Zinc Co., Amax Lead and Zinc, Inc	Blackwell, Okla	
The Eagle-Picher Industries, Inc	Henryetta, Okla	
Matthiessen & Hegeler Zinc Co.[1]	LaSalle, Ill	
National Zinc Co	Bartlesville, Okla	
Vertical-retort plants:		
Matthiessen & Hegeler Zinc Co	Meadowbrook, W. Va	
The New Jersey Zinc Co	Depue, Ill	
Do	Palmerton, Pa	
St. Joseph Lead Co	Josephtown, Pa	

[1] Plant closed July 1, 1961.

Table 10.—Secondary slab zinc plants by group capacity in the United States in 1968

Company	Plant location	Slab zinc capacity (short tons)
American Smelting and Refining Company	Sand Springs, Okla	55,900
Do	Trenton, N.J	
American Zinc Co	Hillsboro, Ill	
Apex Smelting Co	Chicago, Ill	
Arco Die Cast Metals Co	Detroit, Mich	
W. J. Bullock, Inc	Fairfield, Ala	
General Smelting Co	Bristol, Pa	
Gulf Reduction Co	Houston, Tex	
H. Kramer Co	El Segundo, Calif	
Pacific Smelting Co	Torrance, Calif	
Sandoval Zinc Co	Sandoval, Ill	
Superior Zinc Corp	Bristol, Pa	
Wheeling-Pittsburgh Steel Corp	Martins Ferry, Ohio	

Table 11.—Stocks and consumption of new and old zinc scrap in the United States in 1968

(Short tons)

Class of consumer and type of scrap	Stocks Jan. 1 [1]	Receipts	Consumption			Stocks Dec. 31
			New scrap	Old scrap	Total	
Smelters and distillers:						
New clippings	85	851	776	---	776	160
Old zinc	479	5,047	---	5,111	5,111	415
Engravers' plates	650	3,422	---	3,610	3,610	462
Skimmings and ashes	10,190	66,790	64,093	---	64,093	12,887
Sal skimmings	383	417	416	---	416	384
Die-cast skimmings	2,249	5,837	5,579	---	5,579	2,507
Galvanizers' dross	13,105	73,979	77,436	---	77,436	9,648
Die castings	3,808	39,928	---	41,099	41,099	2,627
Rod and die scrap	197	1,144	---	1,144	1,144	197
Flue dust	1,642	5,496	4,861	---	4,861	2,277
Chemical residues	3,063	12,472	9,254	---	9,254	6,281
Total	35,846	215,378	162,415	50,964	213,379	37,845
Chemical plants, foundries and other manufacturers:						
New clippings	---	---	---	---	---	---
Old zinc	2	3	---	1	1	4
Engravers' plates	---	---	---	---	---	---
Skimmings and ashes	3,786	9,106	11,051	---	11,051	1,841
Sal skimmings	5,100	10,169	9,377	---	9,377	5,892
Die-cast skimmings	---	---	---	---	---	---
Galvanizers' dross	---	---	---	---	---	---
Die castings	25	310	---	321	321	14
Rod and die scrap	20	73	---	48	48	45
Flue dust	394	3,056	3,243	---	3,243	207
Chemical residues	1,177	25,282	25,336	---	25,336	1,123
Total	10,504	47,999	49,007	370	49,377	9,126
All classes of consumers:						
New clippings	85	851	776	---	776	160
Old zinc	481	5,050	---	5,112	5,112	419
Engravers' plates	650	3,422	---	3,610	3,610	462
Skimmings and ashes	13,976	75,896	75,144	---	75,144	14,728
Sal skimmings	5,483	10,586	9,793	---	9,793	6,276
Die-cast skimmings	2,249	5,837	5,579	---	5,579	2,507
Galvanizers' dross	13,105	73,979	77,436	---	77,436	9,648
Die castings	3,828	40,233	---	41,420	41,420	2,641
Rod and die scrap	217	1,217	---	1,192	1,192	242
Flue dust	2,036	8,552	8,104	---	8,104	2,484
Chemical residues	4,240	37,754	34,590	---	34,590	7,404
Total	46,350	263,377	211,422	51,334	262,756	46,971

[1] Figures partly revised.

Table 12.—Production of zinc products from zinc-base scrap in the United States

(Short tons)

Product	1964	1965	1966	1967	1968
Redistilled slab zinc	71,596	83,619	83,263	73,505	79,865
Zinc dust	29,742	33,512	34,326	32,801	37,908
Remelt spelter	3,646	5,324	6,970	4,831	3,580
Remelt die-cast slab	8,934	14,760	13,003	14,520	14,570
Zinc-die and diecasting alloys	5,116	5,463	4,333	3,882	4,128
Galvanizing stocks	1,684	1,450	1,585	1,690	2,107
Secondary zinc in chemical products	36,130	47,997	39,834	38,289	45,654

Table 13.—Zinc recovered from scrap processed in the United States, by kind of scrap and form of recovery

(Short tons)

Kind of scrap	1967	1968	Form of recovery	1967	1968
New scrap:			As metal:		
Zinc-base	129,774	144,039	By distillation:		
Copper-base	106,637	127,463	Slab zinc [1]	72,595	78,631
Aluminum-base	2,895	3,100	Zinc dust	32,309	37,334
Magnesium-base	234	324	By remelting	6,366	5,500
Total	239,540	274,926	Total	111,270	121,465
Old scrap:			In zinc-base alloys	17,273	17,532
Zinc-base	40,862	41,408	In brass and bronze	146,441	163,490
Copper-base	36,142	35,390	In aluminum-base alloys	6,145	6,041
Aluminum-base	3,165	2,900	In magnesium-base alloys	431	541
Magnesium-base	140	99	In chemical products:		
			Zinc oxide (lead-free)	17,255	19,316
Total	80,309	79,797	Zinc sulfate	9,536	11,860
			Zinc chloride	11,236	13,347
Grand total	319,849	354,723	Miscellaneous	262	1,131
			Total	208,579	233,258
			Grand total	319,849	354,723

[1] Includes zinc content of redistilled slab made from remelt die-cast slab.

Table 14.—Zinc dust produced in the United States

Year	Short tons	Value		Year	Short tons	Value	
		Total (thousands)	Average per pound			Total (thousands)	Average per pound
1964	45,979	$15,725	$0.171	1967	50,273	$18,098	$0.180
1965	51,958	19,328	.186	1968	61,566	22,041	.179
1966	55,485	20,418	.184				

Table 15.—Consumption of zinc in the United States

(Short tons)

	1964	1965	1966	1967	1968
Slab zinc	1,207,268	1,354,092	1,410,197	1,236,808	1,333,699
Ores (recoverable zinc content)[1]	105,948	122,892	126,696	114,301	124,109
Secondary (recoverable zinc content)[2]	222,535	265,083	269,650	240,888	270,592
Total	1,535,751	1,742,067	1,806,543	1,591,997	1,728,400

[1] Includes ore used directly in galvanizing.
[2] Excludes redistilled slab and remelt zinc.

Table 16.—Slab zinc consumption in the United States, by industry use

(Short tons)

Industry and product	1964	1965	1966	1967	1968
Galvanizing:					
Sheet and strip	257,328	270,826	264,312	236,135	256,319
Wire and wire rope	42,793	43,884	39,114	36,745	36,089
Tubes and pipe	62,166	63,224	68,848	61,792	63,621
Fittings (for tube and pipe)	8,802	8,641	10,150	11,768	13,801
Tanks and containers	NA	NA	4,285	4,137	3,815
Structural shapes	NA	NA	17,838	18,779	20,238
Fasteners	NA	NA	4,340	4,234	4,826
Pole-line hardware	NA	NA	11,400	9,985	9,050
Fencing, wire cloth, and netting	NA	NA	15,821	16,544	15,984
Job galvanizing	44,354	51,011	NA	NA	NA
Other and unspecified uses	40,893	44,835	59,859	58,486	58,074
Total	456,336	482,421	495,967	458,605	481,817
Brass products:					
Sheet, strip, and plate	64,701	58,864	97,095	67,237	86,185
Rod and wire	47,246	45,510	60,079	40,759	49,888
Tube	10,402	10,030	12,148	8,884	9,818
Castings and billets	3,258	3,050	3,378	2,295	2,286
Copper-base ingots	8,565	7,402	9,352	8,121	12,153
Other copper-base products	923	1,992	3,500	4,241	1,576
Total	135,095	126,848	185,552	131,537	161,906
Zinc-base alloy:					
Die casting alloy	517,354	629,809	596,371	525,960	551,896
Dies and rod alloy	604	535	495	420	807
Slush and sand casting alloy	6,624	7,626	9,170	8,738	10,243
Total	524,582	637,970	606,036	535,118	562,946
Rolled zinc	44,181	45,882	52,612	45,443	48,943
Zinc oxide	19,991	25,781	28,438	29,774	34,937
Other uses:					
Wet batteries	1,168	1,188	1,529	1,284	1,823
Desilverizing lead	2,393	2,444	2,776	1,394	2,978
Light-metal alloys	4,769	8,124	10,239	8,805	8,422
Other [1]	18,753	23,434	27,048	24,848	29,932
Total	27,083	35,190	41,592	36,331	43,150
Grand total	1,207,268	1,354,092	1,410,197	1,236,808	1,333,699

NA Not available.

[1] Includes zinc used in making zinc dust, bronze powder, alloys, chemicals, castings, and miscellaneous uses not elsewhere mentioned.

Table 17.—Slab zinc consumption in the United States in 1968, by grades and industry use

(Short tons)

Industry	Special high grade	High grade	Intermediate	Brass special	Prime [1] western	Remelt	Total
Galvanizing	25,574	22,665	1,385	111,225	318,699	2,269	481,817
Brass and bronze	49,825	70,436	115	5,684	33,453	2,393	161,906
Zinc-base alloys	559,767	1,228	42	413	918	578	562,946
Rolled zinc	21,274	13,424	6,093	8,152	---------	---------	48,943
Zinc oxide	5,919	12,203	---------	---------	16,815	---------	34,937
Other	20,948	2,560	343	10,097	9,163	39	43,150
Total	683,307	122,516	7,978	135,571	379,048	5,279	1,333,699

[1] Includes select grade.

Table 18.—Rolled zinc produced and quantity available for consumption in the United States

	1967			1968		
	Short tons	Value		Short tons	Value	
		Total (thousands)	Average per pound		Total (thousands)	Average per pound
Production:[1]						
Photoengraving plate	12,002	$9,004	$0.375	12,004	$8,703	$0.363
Other plate over 0.375 inch thick	W	W	W	W	W	W
Sheet zinc less than 0.375 inch thick	W	W	W	W	W	W
Strip and foil	29,028	13,225	.228	31,468	14,037	.223
Rod and wire	W	W	W	W	W	W
Total rolled zinc	44,240	24,652	.279	47,524	25,804	.272
Imports	648	276	.213	754	290	.192
Exports	3,565	2,709	.380	3,048	2,228	.365
Available for consumption	41,034	--------	--------	45,313	--------	--------
Value of slab zinc (all grades)	--------	--------	.140	--------	--------	.135
Value added by rolling	--------	--------	.139	--------	--------	.137

W Withheld to avoid disclosing individual company confidential data, included in total.

[1] Figures represent net production. In addition, 18,672 tons in 1967 and 21,936 tons in 1968 were rerolled from scrap originating in fabricating plants operating in connection with zinc rolling mills.

Table 19.—Slab zinc consumption in the United States in 1968, by industries and States

(Short tons)

State	Galvanizers	Brass mills [1]	Die casters [2]	Other [3]	Total
Alabama	39,008	W	---------	W	40,172
Arizona	W	---------	---------	W	W
Arkansas	---------	---------	---------	W	W
California	36,725	2,675	13,208	2,418	55,026
Colorado	W	W	W	---------	3,355
Connecticut	3,133	43,163	W	W	52,190
Delaware	W	W	W	---------	1,498
Florida	3,074	---------	W	---------	W
Georgia	W	---------	W	---------	W
Hawaii	W	---------	---------	---------	W
Idaho	---------	---------	W	W	W
Illinois	46,302	35,235	86,006	W	196,715
Indiana	69,249	W	45,834	W	152,409
Iowa	719	---------	---------	W	1,569
Kansas	---------	W	W	---------	W
Kentucky	W	W	---------	W	18,894
Louisiana	1,252	---------	---------	---------	1,252
Maine	W	---------	---------	---------	W
Maryland	29,058	W	---------	W	W
Massachusetts	2,913	W	---------	W	8,490
Michigan	4,832	15,731	132,245	W	158,368
Minnesota	2,510	W	---------	W	W
Mississippi	W	---------	---------	---------	W
Missouri	7,736	W	W	W	18,244
Montana	---------	---------	---------	W	W
Nebraska	1,203	W	---------	W	2,063
New Hampshire	---------	W	---------	---------	W
New Jersey	3,170	5,639	W	2,565	W
New York	13,252	11,807	72,879	W	104,701
North Carolina	W	---------	W	W	1,504
Ohio	92,701	W	86,425	1,205	W
Oklahoma	4,742	---------	W	W	10,095
Oregon	588	W	W	---------	1,154
Pennsylvania	63,481	W	25,664	W	144,875
Rhode Island	W	W	---------	W	628
South Carolina	W	---------	---------	---------	W
South Dakota	W	---------	---------	---------	W
Tennessee	745	---------	W	W	2,507
Texas	15,031	W	W	W	41,281
Utah	W	W	---------	---------	761
Virginia	281	34	W	W	1,325
Washington	896	---------	---------	1,139	2,035
West Virginia	10,864	W	---------	W	13,374
Wisconsin	1,215	6,371	9,968	10	17,564
Undistributed	24,868	39,358	90,139	119,654	281,371
Total [4]	479,548	159,513	562,368	126,991	1,328,420

W Withheld to avoid disclosing individual company confidential data; included with "Undistributed."

[1] Includes brass mills, brass ingot makers, and brass foundries.

[2] Includes producers of zinc-base alloy for diecastings, stamping dies, and rods.

[3] Includes slab zinc used in rolled zinc products and in zinc oxide.

[4] Excludes remelt zinc.

Table 20.—Production and shipments of zinc pigments and compounds[1] in the United States

Pigment or compound	1967				1968			
	Production (short tons)	Shipments			Production (short tons)	Shipments		
		Short tons	Value [2]			Short tons	Value [2]	
			Total (thousands)	Average per ton			Total (thousands)	Average per ton
Zinc oxide [3]	187,208	181,486	$50,300	$277	209,963	213,826	$58,944	$276
Leaded zinc oxide [3]	9,699	10,306	2,596	252	11,125	7,995	2,030	254
Zinc chloride, 50° B [4]	50,853	51,229	W	W	57,914	57,508	W	W
Zinc sulfate	48,847	48,800	8,437	173	57,131	59,647	10,357	174

W Withheld to avoid disclosing individual company confidential data.

[1] Excludes lithopone; figure withheld to avoid disclosing individual company confidential data.

[2] Value at plant, exclusive of container.

[3] Zinc oxide containing 5 percent or more lead is classed as leaded zinc oxide.

[4] Includes zinc chloride equivalent of zinc ammonium chloride and chromated zinc chloride.

Table 21.—Zinc content of zinc pigments[1] and compounds produced by domestic manufacturers, by sources

(Short tons)

Pigment or compound	1967					1968				
	Zinc in pigments and compounds produced from—				Total zinc in pigments and compounds	Zinc in pigments and compounds produced from—				Total zinc in pigments and compounds
	Ore		Slab zinc	Secondary material		Ore		Slab zinc	Secondary material	
	Domestic	Foreign				Domestic	Foreign			
Zinc oxide	65,719	29,057	29,774	25,131	149,681	80,218	23,651	36,541	27,366	167,776
Leaded zinc oxide	3,235	2,922	------	------	6,157	3,231	3,886	------	------	7,117
Total	68,954	31,979	29,774	25,131	155,838	83,449	27,537	36,541	27,366	174,893
Zinc chloride [2]	------	------	W	W	12,080	------	------	W	W	14,073
Zinc sulfate	3,430	4,076	------	W	16,015	3,809	3,955	------	10,701	18,465

W Withheld to avoid disclosing individual company confidential data.

[1] Excludes zinc sulfide and lithopone; figures withheld to avoid disclosing individual company confidential data.

[2] Includes zinc content of zinc ammonium chloride and chromated zinc chloride.

Table 22.—Distribution of zinc oxide and leaded zinc oxide shipments, by industries

(Short tons)

Industry	1964	1965	1966	1967	1968
Zinc oxide:					
Rubber	93,568	103,057	104,866	94,388	111,797
Paints	31,176	30,249	27,100	24,547	25,864
Ceramics	9,447	10,009	12,147	9,850	10,226
Chemicals	NA	11,365	13,678	17,509	22,769
Agriculture	NA	977	1,559	5,048	5,044
Photocopying	NA	W	11,405	14,039	21,564
Coated fabrics and textiles	W	W	W	W	W
Floor covering	438	363	W	W	W
Other	39,674	30,550	22,910	16,105	16,562
Total	174,303	186,570	193,665	181,486	213,826
Leaded zinc oxide:					
Paints	13,124	10,951	10,462	8,644	6,356
Rubber	489	899	1,095	1,662	1,639
Other and unspecified					
Total	13,613	11,850	11,557	10,306	7,995

NA Not available.
W Withheld to avoid disclosing individual company confidential data, included with "Other."

Table 23.—Distribution of zinc sulfate shipments, by industries

(Short tons)

Year	Rayon		Agriculture		Other		Total	
	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis	Gross weight	Dry basis
1964	18,066	16,103	11,248	9,807	17,292	11,231	46,606	37,141
1965	21,204	18,886	14,331	12,449	15,009	10,637	50,544	41,972
1966	18,659	16,562	19,334	16,891	13,705	9,372	51,698	42,825
1967	W	W	17,156	14,803	31,644	24,742	48,800	39,545
1968	W	W	20,472	17,631	39,748	36,470	60,220	54,101

W Withheld to avoid disclosing individual company confidential data, included with "Other."

Table 24.—U.S. exports of zinc pigment

Kind	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc oxide	3,440	$1,064	3,640	$1,202
Lithopone	735	267	1,300	281
Total	4,175	1,331	4,940	1,483

Table 25.—U.S. imports for consumption of zinc pigments and compounds

Kind	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Zinc arsenate	--------	-------	2	$6
Zinc oxide	13,767	$2,567	15,551	3,072
Zinc sulfide	431	143	534	176
Lithopone	116	22	246	37
Zinc chloride	1,167	197	2,063	412
Zinc sulfate	3,291	351	2,196	235
Zinc cyanide	46	35	92	66
Zinc compounds n.s.p.f.	170	89	154	148
Total	18,988	3,404	20,838	4,152

Table 26.—Stocks of zinc at zinc-reduction plants in the United States, Dec. 31

(Short tons)

	1964	1965	1966	1967	1968
At primary reduction plants	30,680	27,635	63,626	81,307	62,428
At secondary distilling plants	498	987	1,172	609	684
Total	31,178	28,622	64,798	81,916	63,112

Table 27.—Consumers stocks of slab zinc at plants, Dec. 31, by grades

(Short tons)

Date	Special high grade	High grade	Intermediate	Brass special	Prime western	Remelt	Total
Dec. 31, 1967	35,444	11,202	630	8,750	46,239	270	[r] 102,535
Dec. 31, 1968	48,180	6,418	454	6,567	40,577	242	102,438

[r] Revised.

Table 28.—Average monthly quoted prices of 60-percent zinc concentrate at Joplin, and common zinc (prompt delivery or spot), East St. Louis and London[1]

Month	1967			1968		
	60-percent zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)		60-percent zinc concentrates in the Joplin region (per ton)	Metallic zinc (cents per pound)	
		East St. Louis	London[2][3]		East St. Louis	London[2][3]
January	$92.00	14.50	12.68	$84.00	13.50	12.03
February	92.00	14.50	12.80	84.00	13.50	11.88
March	92.00	14.50	12.67	84.00	13.50	11.67
April	92.00	14.50	12.84	84.00	13.50	11.68
May	88.40	13.65	12.48	84.00	13.50	11.77
June	86.00	13.57	12.44	84.00	13.50	11.75
July	84.00	13.50	12.03	84.00	13.50	12.03
August	84.00	13.50	12.09	84.00	13.50	12.17
September	84.00	13.50	11.91	84.00	13.50	11.90
October	84.00	13.50	11.88	84.00	13.50	11.83
November	84.00	13.50	12.40	84.00	13.50	11.95
December	84.00	13.50	12.06	84.00	13.50	12.06
Average for year	87.20	13.85	12.37	84.00	13.50	11.89

[1] Joplin: Metal Statistics, 1969. East St. Louis: Metal Statistics, 1969. London: Metals Week.

[2] Conversion of English quotations into U.S. money based on average rates of exchange recorded by Federal Reserve Board.

[3] Average of daily mean of bid and asked quotations at morning session of London Metal exchange.

Table 29.—U.S. exports of slab and sheet zinc, by countries

Destination	Slabs, pigs, and blocks						Sheets, plates, strips, or other forms, n.e.c.					
	1966		1967		1968		1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands
Argentina	-------	-------	(1)	(1)	-------	-------	29	$23	42	$34	38	$32
Australia	-------	-------	-------	-------	1	$1	42	30	24	22	32	26
Belgium-Luxembourg	-------	-------	-------	-------	-------	-------	-------	-------	11	11	4	4
Brazil	61	$18	188	$57	-------	-------	44	37	7	6	20	18
Canada	191	212	1,198	530	326	165	2,059	1,459	1,934	1,528	1,976	1,414
Chile	69	30	142	59	130	46	102	86	59	51	35	27
China, mainland	2	2	42	24	23	11	6	4	3	5	47	34
Colombia	21	8	93	30	5	2	49	43	34	34	69	64
Denmark	-------	-------	(1)	(1)	-------	-------	48	44	34	30	12	10
Germany, West	1	(1)	451	118	4	2	773	334	18	18	115	84
India	4	2	13,724	3,122	32,345	9,507	3	7	-------	-------	1	1
Iran	-------	-------	-------	-------	12	4	-------	-------	-------	-------	22	7
Israel	-------	-------	-------	-------	3	3	25	19	39	30	36	26
Italy	1	1	-------	-------	2	1	33	26	7	6	(1)	1
Mexico	29	23	6	4	1	1	18	20	32	45	17	18
Netherlands	-------	-------	-------	-------	2	1	48	47	18	17	-------	-------
New Zealand	-------	-------	-------	-------	-------	-------	23	16	48	33	7	7
Philippines	-------	-------	350	105	122	35	30	22	12	7	9	7
South Africa, Republic of	-------	-------	-------	-------	-------	-------	149	124	113	98	87	76
Spain	47	30	25	15	-------	-------	21	15	18	15	1	2
Sweden	-------	-------	-------	-------	-------	-------	22	22	26	28	1	1
Switzerland	-------	-------	-------	-------	-------	-------	20	16	27	22	6	6
Turkey	-------	-------	357	109	-------	-------	2	1	-------	-------	-------	-------
United Kingdom	2	2	-------	-------	1	1	148	105	149	125	60	38
Venezuela	512	226	148	81	7	4	332	185	188	127	103	94
Vietnam, South	46	18	67	24	-------	-------	664	305	481	212	-------	-------
Other	420	177	18	9	27	13	231	208	241	205	350	231
Total	1,406	749	16,809	4,287	33,011	9,797	4,921	3,198	3,565	2,709	3,048	2,228

---

[1] Less than ½ unit.

Table 30.—U.S. exports of zinc by classes

Year	Slabs, pigs, or blocks		Sheets, plates, strips, or other forms, n.e.c.		Zinc scrap and dross (zinc content)		Semifabricated forms, n.e.c.	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands
1966	1,406	$749	4,921	$3,198	4,469	$702	3,034	$1,894
1967	16,809	4,287	3,565	2,709	1,665	530	2,161	1,177
1968	33,011	9,797	3,048	2,228	2,293	886	15,000	3,840

Table 31.—U.S. imports of zinc, by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
ORES						
Algeria	164	$24	9,264	$1,258	---------	---------
Australia	4,334	842	4,836	701	2,267	$410
Bolivia	5,788	903	9,576	1,450	9,027	1,510
Canada	272,950	36,508	289,387	42,045	310,586	46,625
Germany, West	9,685	1,627	6,248	941	5,942	881
Guatemala	318	63	---------	---------	---------	---------
Honduras	10,776	1,499	9,727	1,362	12,959	1,759
Mexico	114,677	13,346	119,135	13,839	142,318	16,352
Morocco	7,407	1,177	6,516	862	15,715	1,426
Netherlands	3,198	580	---------	---------	3,313	418
Peru	78,254	11,081	69,357	9,646	39,899	6,071
South Africa, Republic of	12,565	2,261	8,419	1,686	4,287	643
Yugoslavia	769	116	---------	---------	---------	---------
Other	435	66	1,627	220	74	15
Total	521,320	70,093	534,092	74,010	546,382	76,110
BLOCKS, PIGS, OR SLABS						
Australia	27,007	7,583	7,187	1,703	19,915	4,627
Belgium-Luxembourg	27,469	7,012	16,100	3,995	16,500	4,080
Canada	116,778	32,591	80,487	21,784	118,701	30,439
Congo (Kinshasa)	12,814	3,357	2,921	728	8,146	1,850
Germany, West	6,062	1,562	939	259	---------	---------
Japan	19,805	5,274	41,621	10,483	45,735	11,115
Mexico	22,702	5,368	18,673	4,385	19,034	4,150
Norway	4,032	1,077	3,753	951	6,272	1,555
Peru	30,805	8,556	33,568	8,873	53,729	13,655
Poland	5,421	1,452	9,870	2,607	9,454	2,366
Spain	926	145	2,094	564	2,877	691
United Kingdom	258	76	1,145	251	3,398	803
Yugoslavia	551	146	474	130	---------	---------
Other	3,545	827	3,280	789	2,779	675
Total	278,175	75,026	222,112	57,502	306,540	76,006

Table 32.—U.S. imports for consumption of zinc, by classes

Year	Ore (zinc content)		Blocks, pigs, and slabs		Sheets, plates, strips, and other forms	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
1966	396,375	$51,696	280,307	$75,624	1,708	$670
1967	431,319	58,075	222,002	57,531	648	276
1968	481,787	68,466	306,651	76,035	754	290

Year	Old and worn out		Dross and skimmings		Zinc dust		Total value [1] (thousands)
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)	
1966	2,032	$402	4,531	$893	1,286	$398	$129,683
1967	1,465	240	2,498	433	3,771	1,211	117,766
1968	878	119	581	63	8,100	2,443	147,416

[1] In addition, manufactures of zinc were imported as follows: 1966, $545,003; 1967: $318,287; 1968: $446,555.

Table 33.—U.S. imports for consumption of zinc, by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
ORES						
Algeria	164	$24	9,264	$1,258	727	$122
Australia	---------	---------	3,334	358	1,236	235
Bolivia	321	65	137	13	5,603	950
Canada	233,093	30,842	274,854	38,584	301,306	44,459
Germany, West	5,945	964	24	5	---------	---------
Guatemala	318	63	---------	---------	9	1
Honduras	677	143	1,612	268	6,531	925
Mexico	87,112	9,588	83,653	9,228	101,554	11,204
Morocco	2,784	536	3,318	414	15,675	1,897
Netherlands	---------	---------	---------	---------	3,313	418
Peru	52,718	7,118	45,274	6,074	40,237	7,368
South Africa, Republic of	12,440	2,241	9,584	1,845	5,466	857
Other	803	117	265	28	130	30
Total	396,375	51,696	431,319	58,075	481,787	68,466
BLOCKS, PIGS, OR SLABS						
Australia	27,007	7,583	7,187	1,703	19,915	4,627
Belgium-Luxembourg	27,469	7,012	15,989	4,016	16,611	4,109
Canada	116,758	32,588	80,482	21,791	118,701	30,439
Congo (Kinshasa)	12,814	3,357	2,921	728	8,146	1,850
Germany, West	6,063	1,562	939	259	---------	---------
Japan	21,712	5,818	41,621	10,483	45,735	11,115
Mexico	22,773	5,383	18,673	4,385	19,034	4,150
Norway	4,032	1,077	3,753	951	6,272	1,555
Peru	30,854	8,568	33,568	8,873	53,729	13,655
Poland	5,421	1,452	9,870	2,607	9,454	2,366
Spain	1,050	183	2,094	564	2,877	691
United Kingdom	258	76	1,145	250	3,398	803
Yugoslavia	551	146	474	130	---------	---------
Other	3,545	819	3,286	791	2,779	675
Total	280,307	75,624	222,002	57,531	306,651	76,035

Table 34.—World mine production of zinc (content of ore), by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 [p]
North America:					
Canada	729,939	910,928	1,046,968	1,248,965	1,273,249
Guatemala (exports)	----------	[r] 956	[r] 995	[r] 478	NA
Honduras	9,445	12,265	13,661	14,425	16,295
Mexico	259,708	247,883	241,604	[r] 265,891	264,575
United States (recoverable)	574,858	611,153	572,558	549,413	529,446
South America:					
Argentina	25,257	32,715	[r] 29,151	29,981	[e] 30,000
Bolivia	10,523	14,999	17,646	18,468	12,991
Brazil	----------	5,750	NA	NA	[e] 5,300
Chile	1,108	1,524	[r] 1,486	1,238	1,383
Colombia [e]	110	50	330	[r] 600	600
Ecuador	420	260	149	177	126
Peru	260,873	280,533	284,196	[r] 335,980	340,720
Europe:					
Austria	8,004	7,609	8,568	8,952	9,894
Bulgaria	70,775	73,036	[e] 90,000	[e] 88,200	[e] 88,200
Finland	69,436	76,070	59,938	67,020	72,090
France	18,564	23,040	25,677	27,193	[e] 24,800
Germany:					
East [e]	11,000	11,000	13,000	13,200	13,200
West	122,699	120,284	[r] 117,910	126,252	121,471
Greece [e]	11,410	11,660	8,600	11,500	11,700
Hungary [e]	3,100	3,600	3,600	NA	NA
Ireland	----------	1,584	27,300	33,069	58,422
Italy	[r] 130,414	[r] 127,316	[r] 128,308	137,457	154,102
Norway	13,771	14,261	14,673	13,417	[e] 12,800
Poland	166,100	167,700	165,700	172,620	[e] 174,200
Portugal	1,049	3,254	2,585	559	504
Spain	97,509	43,283	[r] 63,079	65,154	83,389
Sweden	85,070	[r] 87,214	[r] 92,084	90,168	89,617
U.S.S.R. [e]	470,000	520,000	550,000	589,700	595,200
Yugoslavia	101,193	101,213	96,121	99,226	[e] 110,200
Africa:					
Algeria	38,932	42,334	[e] 13,000	[e] 11,000	[e] 11,000
Congo (Brazzaville)	5,578	[e] 7,600	[e] 7,600	[e] 6,600	NA
Congo (Kinshasa)	116,338	131,345	126,600	133,981	139,473
Morocco	46,678	56,458	59,218	50,178	35,032
South-West Africa, Territory of	35,311	32,936	31,132	[r] [e] 44,100	[e] 66,100
Tunisia	3,681	5,222	6,387	4,577	5,622
Zambia	52,000	52,200	70,100	49,476	59,304
Asia:					
Burma	8,438	8,579	[e] 7,000	[e] 5,100	4,409
China, mainland [e]	110,000	110,000	110,000	99,200	110,200
India	6,520	5,861	5,386	[r] 5,808	7,681
Iran [2] [e]	17,000	17,000	19,000	26,500	27,600
Japan	238,602	243,633	279,577	[r] 289,551	291,300
Korea:					
North [e]	110,000	115,000	115,000	126,800	126,800
South	2,800	7,844	12,889	[r] 15,045	21,318
Philippines	2,355	2,270	1,817	1,706	2,472
Thailand	1,520	2,326	[e] 2,600	----------	----------
Turkey	6,268	8,000	3,770	4,066	5,377
Oceania: Australia	385,953	391,139	413,655	447,528	463,409
Total [3]	[r] 4,440,309	[r] 4,750,887	[r] 4,960,613	5,330,519	5,471,071

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] Czechoslovakia produces concentrate for export, and Rumania and North Vietnam also produce zinc, but data are not available.

[2] Year ended March 20 of year following that stated.

[3] Totals are of listed figures only.

Table 35.—World smelter production of zinc, by countries[1]

(Short tons)

Country[2]	1964	1965	1966	1967	1968 p
North America:					
Canada	337,728	r 358,494	382,612	405,094	426,929
Mexico	65,506	69,158	78,909	78,110	88,226
United States	954,084	994,402	1,025,066	938,830	1,020,891
South America:					
Argentina	24,500	26,000	24,563	e 25,400	e 23,100
Brazil	----------	r 54	1,481	r 1,975	5,291
Peru	68,016	68,829	69,033	69,443	75,085
Europe:					
Austria	14,215	14,455	15,654	15,605	16,859
Belgium[3]	245,308	264,300	277,500	250,584	280,315
Bulgaria	64,657	72,492	66,000	e 81,500	e 80,500
France	209,706	211,683	216,043	204,697	228,507
Germany:					
East e	11,000	11,000	13,000	15,400	15,400
West	117,988	118,724	135,558	113,154	134,481
Italy	80,483	89,175	85,130	98,133	123,760
Netherlands	41,559	44,997	45,588	r 42,663	47,514
Norway	53,304	57,955	56,350	60,407	66,161
Poland	206,000	209,900	213,000	216,051	228,216
Spain	71,023	58,991	r 59,227	77,610	83,099
U.S.S.R. (primary) e	r 490,500	590,000	r 562,200	595,200	595,200
United Kingdom	122,396	117,742	111,715	114,970	157,491
Yugoslavia	49,066	50,778	56,316	58,629	87,059
Africa:					
Congo (Kinshasa)	61,237	62,853	67,800	67,783	68,974
Zambia	51,491	52,289	46,600	49,035	58,574
Asia:					
China, mainland (refined) e	100,000	100,000	100,000	88,200	99,200
India	----------	----------	----------	r 3,350	22,817
Japan	348,420	405,433	489,598	r 569,028	667,504
Korea:					
North e	75,000	80,000	80,000	88,200	88,200
South	----------	----------	1,570	2,809	2,705
Oceania: Australia	207,795	222,867	217,739	217,807	230,138
Total[4]	r 4,070,982	r 4,352,571	r 4,498,252	4,549,667	5,017,196

e Estimate. p Preliminary. r Revised.

[1] Data derived in part from the International Lead and Zinc Study Group Monthly Bulletin; Yearbook of the American Bureau of Metal Statistics; the United Nations Monthly Bulletin and Statistical Yearbook; Statistical Summary of the Mineral Industry (Overseas Geological Surveys, London); and Metal Statistics (Metallgesellschaft), West Germany.

[2] Czechoslovakia, North Vietnam, and Rumania also produce zinc, but production data are not available.

[3] Includes production from reclaimed scrap.

[4] Totals are of listed figures only.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-739/63

Zirconium and Hafnium

By John G. Parker[1]

The domestic production of zircon in 1968 was only slightly less than it was in 1967. Consumption, however, rose almost 7 percent and consumers had to draw on their stocks.

Metal sponge production advanced by nearly 60 percent, owing to increased orders for zirconium alloys for nuclear reactors. Zircon usage in foundries also increased, as did production of milled zircon. Net imports of zircon increased about 2 percent to nearly 58,000 tons; Australia supplied 98 percent of the total.

Legislation and Government Programs.—Stocks of non-objective zirconium mineral concentrate in the national stockpile remained at 16,514 tons of Brazilian baddeleyite, with a content of 11,162 tons of zirconium dioxide (zirconia) and 1,721 tons of low-grade material, with a content of 398 tons of zirconium dioxide. The Atomic Energy Commission had a yearend inventory of 1,150 tons of zirconium sponge and 38.5 tons of hafnium crystal bar.

Table 1.—Salient zirconium and hafnium statistics in the United States

(Short tons)

	1967	1968
Zircon:		
Production	W	W
Exports	2,729	2,026
Imports	59,303	59,900
Consumption [e]	134,000	143,000
Stocks, yearend, dealers and consumers [1]	48,000	46,000
Zirconium oxide:		
Production [2]	[r] 3,865	3,864
Producers' stocks, yearend [3]	[r] 1,267	1,077

[e] Estimate. [r] Revised.

W Withheld to avoid disclosing individual company confidential data.

[1] Excludes foundries.

[2] Excludes that used in metal manufacture.

[3] Excludes that used in metal manufacture and the equivalent zirconia content of refractories.

DOMESTIC PRODUCTION

Byproduct zircon from the processing of titaniferous mineral sands was obtained from two dredges and a milling facility owned and operated by E. I. du Pont de Nemours & Co., Inc., on the Trail Ridge deposit, Florida. Additional output came from a dredge and mill run by Humphreys Mining Co. for Du Pont near Folkston, Georgia. Carpco Research and Engineering, Inc. recovered a small quantity of zircon from tailings at the old Skinner mines, owned by National Lead Co. near Jacksonville, Fla., early in the year and then ceased operations.

Five companies produced 44,100 tons of milled (or ground) zircon, an increase of 11 percent from the revised 1967 figure of 39,800 tons. The production of zirconium dioxide by four companies for other than metal manufacture amounted to almost the same as the corrected total of 3,865 tons for 1967. Output of refractories containing an average of about 50 percent zirconium dioxide (zirconia) remained at nearly 25,000 tons.

Owing to proprietary restrictions, production of zirconium sponge metal cannot be published, but it showed an increase of nearly 60 percent from that of 1967, thus reflecting an increased demand for the metal by the nuclear industry.

Ingot production was 1,902 tons, an increase of 50 percent over 1967, but powder output dropped to 73 tons. Miscellaneous milled and fabricated products, exclusive of tubing, more than doubled. Scrap recovery increased over 8 percent to 314 tons. Zirconium alloys exclusive of Zircaloy but including large quantities of ferrozirconium, rose 15 percent to 4,309 tons.

---

[1] Physical scientist, Division of Mineral Studies.

Producers of zirconium materials (including zircon and finished products) in 1968 were as follows:

Company	*Location*	*Materials*
Amax Specialty Metals, Inc	Akron, N.Y	Oxide, ingot.
Do	Parkersburg, W. Va	Sponge metal.
Continental Mineral Processing Co	Sharonville, Ohio	Milled zircon.
Corhart Refractories Co	Buckhannon, W. Va	Zircon and zirconia refractories.
Do	Corning, N.Y	Do.
Do	Louisville, Ky	Do.
Foote Mineral Co	Exton, Pa	Metal powder, alloys.
E. I. duPont de Nemours & Co., Inc	Trail Ridge, Fla	Zircon.
Do	Folkston, Ga	Do.
Frank Samuel & Co., Inc.[1]	Camden, N.J	Milled zircon.
A. P. Green Refractories Co., Remmey Division	Philadelphia, Pa	Zircon and zirconia refractories.
Harbison-Carborundum Corp	Falconer, N.Y	Do.
Harbison-Walker Refractories Co	Mount Union, Pa	Do.
Harvey Aluminum, Inc	Torrance, Calif	Ingot.
M & T Chemicals, Inc	Andrews, South Carolina	Milled zircon.
Do	Rahway, N.J	Chloride.
National Lead Co., Titanium Alloy Manufacturing Division (TAM).	Jacksonville, Fla	Zircon.
Do	Niagara Falls, N.Y	Milled zircon, oxide, compounds, metal powder, alloys.
Norton Co	Huntsville, Ala	Oxide.
Nuclear Materials & Equipment Corp. (NUMEC)	Apollo, Pa	Metal powder.
Ohio Ferro-Alloys Corp	Canton, Ohio	Alloys.
Shieldalloy Corp	Newfield, N.J	Milled zircon, alloys.
Stauffer Chemical Co	Niagara Falls, N.Y	Chloride.
The Chas. Taylor Sons Co	Cincinnati, Ohio	Zircon and zirconia refractories.
Do	South Shore, Ky	Do.
Tizon Chemical Corp	Flemington, N.J	Oxide, compounds.
Transelco, Inc	Penn Yan, N.Y	Compounds, alloys.
Union Carbide Corp	Niagara Falls, N.Y	Alloys.
Do	Alloy, W. Va	Do.
Ventron Corp., Metal Chemicals Division [2]	Beverly, Mass	Do.
Wah Chang Albany Corp	Albany, Oreg	Oxide, sponge metal, ingot, metal powder.
Walsh Refractories Corp	St. Louis, Mo	Zircon and zirconia refractories.
Zirconium Corporation of America (ZIRCOA)	Solon, Ohio	Oxide, zircon and zirconia refractories.

Producers of hafnium materials in 1968 were as follows:

Amax Specialty Metals, Inc	Parkersburg, W. Va	Oxide.
Do	Akron, N.Y	Sponge metal, crystal bar.
NUMEC	Apollo, Pa	Crystal bar.
Wah Chang Albany Corp	Albany, Oreg	Oxide, sponge.

---

[1] Formerly Howmet Corp., Minerals Division.
[2] Formerly Ventron Corp., Metal Hydrides Division.

Commensurate with the increase in zirconium sponge production, output of hafnium oxide increased nearly 50 percent, but output of the sponge dropped nearly 25 percent.

During the year, ZIRCOA was acquired by Pickands Mather & Co. and will be operated as a wholly owned subsidiary affiliated with the parent company's Chemical Division.

Wah Chang Albany Corp. expected to eliminate its old zirconium carbide plant in Albany, Ore. with the 1969 installation of a new operation which uses direct chlorination of zircon sand to produce zirconium tetrachloride. Also in Albany, Zirconium Technology Corp. planned to start construction in 1969 of a new plant for producing seamless zirconium, titanium, and other specialty metal tubing, using a tube reduction rather than the usual drawing method. Sandvik Specialty Metals Corp., Kennewick, Wash., a joint venture of United Nuclear Corp. and the Sandvik Steel Works of Sweden, opened a new 45,000-square-foot plant which had an initial annual capacity of over 1 million feet of zirconium alloy and titanium tubing for the nuclear and aerospace industries.

CONSUMPTION AND USES

In 1968, the estimate for zircon consumption in the United States was 143,000 tons, considerably higher than in 1967, with the increase due mostly to depletion of consumer stocks. Consumption by foundries, for such applications as foundry sand facings, was estimated at about 80,000 tons or 56 percent of the total.

From data received from the principal dealers and consumers of zircon, it was indicated that the ceramic and refractories industries each consumed 16 percent of the total, metals and alloys used 8 percent, and chemicals and other applications required about 4 percent.

Until recently, zircon sand molding material had found increased use, particularly in steel foundries, but price increases plus the availability of lower cost materials such as chromite sand has had an adverse effect. The main advantages of zircon as a molding medium are its properties of high refractoriness, low thermal expansion, chemical stability, high thermal diffusivity, and good bonding.

Finely ground zircon (flour) is used in refractory paints for coating molds, thereby increasing the mold's resistance to metal penetration and giving a good casting surface finish.[2]

In zirconium-bearing refractories, bricks and shapes made from zircon and zirconia are predominate. For statistical purposes, shipments of these materials are expressed in terms of equivalent 9-inch bricks. Preliminary data for 1968 indicated an increase of 16 percent to 1.722 million bricks valued at $5.48 million.[3]

In ceramic enamels and glazes, zirconium compounds, particularly the oxide, are used as opacifiers because of their high light reflectivity and thermal stability.

The output of sponge and the domestic consumption of zirconium metal and alloy increased. The greatest demand was for Zircaloy for cladding fuel tubing owing to its high resistance to corrosion and its transparency to thermal neutrons. In 1968, zirconium sponge requirements for domestic nuclear reactors were 1.3 million pounds, most of which was for government production and Navy reactors, and the rest for commercial light-water reactors. A comprehensive report on zirconium and its alloys was published recently.[4]

The metal was also used as finely shredded foil in camera flash bulbs. An improved, rolled zirconium foil of high purity provided quicker flash ignition and greater and longer light intensity.[5]

Increasing but still relatively small quantities of metal were used as construction materials in various processing plants where its high cost is offset by its excellent anticorrosion properties.

Other applications for zirconium compounds were in the polishing of optical glass where a slurry of zirconium oxide in water is used;[6] in preventing tooth decay, where stannous hexafluorozirconate was said to be more effective than stannous fluoride;[7] and in new polymeric floor finishes, which are resistant to ammonialess detergents, retaining their original gloss through repeated washings and scrubbings.[8]

STOCKS

At yearend, zircon stocks held by dealers and consumers (excluding foundries) totaled 39,500 tons in crude form and 6,500 tons as milled. Total stocks of zirconium oxide were 1,480 tons, slightly less than the revised figure of 1,525 tons for 1967. Yearend stocks of zirconium metal and alloys included the following: 241 tons of sponge, 163 tons of ingot, 659 tons of scrap, 5 tons of powder, and 1,650 tons of alloys (about one-half of which was ferrozirconium) as compared with a revised 1967 total of 1,500 tons of alloys. Yearend stocks of zirconium-bearing refractories increased to 9,550 tons of material with an equivalent oxide content of 4,600 tons. Hafnium oxide stocks were 115 tons, compared with revised stocks of 68 tons of the oxide at yearend 1967. Stocks of hafnium sponge remained almost constant, but those of hafnium crystal bar increased slightly to 5 tons.

---

[2] Middleton, J. M. Zircon: Its Application in the Foundry. Industrial Minerals (London), No. 16, January 1969, pp. 29–31.

[3] U.S. Department of Commerce, Bureau of the Census. Current Industrial Reports. Refractories, First Quarter 1968, Series MQ–32C(68)–1, July 9, 1968; Second Quarter 1968, Series MQ–32C(68)–2, Oct. 11, 1968; Third Quarter 1968, Series MQ–32C(68)–3, Dec. 17, 1968; Fourth Quarter 1968, Series MQ–32C(68)–4, Mar. 28, 1969.

[4] U.S. Atomic Energy Commission. The Nuclear Industry–1968. Nov. 14, 1968, pp. 70–73.

[5] American Metal Market. Foil Users Seeking, Getting Tighter Control of Quality. V. 75, No. 36, Feb. 21, 1968, pp. 4A–5A.

[6] National Glass Budget. Antifoamer Safeguards Quality in Polishing Optical Glass. V. 84, No. 4, May 11, 1968, p. 17.

[7] Chemical & Engineering News. V. 46, No. 11, Mar. 11, 1968, p. 31.

[8] Wertenberger, M. D., Jr. Research Expands the Components of Tomorrow's Floor Finishes. Building Maintenance and Modernization, v. 15, No. 4, April 1968, pp. 30–32, 34.

PRICES AND SPECIFICATIONS

Little effect was noted on the possible weakening of zircon prices owing to increased use of chromite sand as a molding medium in foundries. On the other hand, continued expansion of Australian production capacity might provide a surplus of zircon in a few years. To overcome this, producers might be expected to permit a moderate decline in prices in the near future.

Quotations on zircon, zirconium metal, alloys, compounds, and hafnium metal during 1968 were as follows:

	Price
Zircon:	
Domestic, containing 66 percent ZrO_2, f.o.b. Starke, Fla. bags, per short ton [1]	$56 to 57
Imported, sand, containing 65 percent, ZrO_2, c.i.f. Atlantic ports, in bags, per long ton [1]	70
Domestic, granular, 1- to 5-ton lots, from works, in bags, per pound [2] [3]	.04875
Domestic, milled, 1- to 5-ton lots, from works, in bags, per pound [2] [3]	.055
Zirconium oxide:[2]	
Chemically pure white ground, barrels or bags, works per pound	1.50
Milled, bags, 5-ton lots, from works, per pound	.645
Glass polishing grade, 100 pound bags, 94–97 percent ZrO_2, works, per pound	.92
Opacifier grade, 100 pound bags, 85–90 percent ZrO_2, per pound	.41
Stabilizer oxide, 100 pound bags, 91 percent ZrO_2, milled, per pound	.75 to 0.85
Zirconium hydride:[2]	
Electronic grade, powder, drums, from works, per pound	14.50 to 16.00
Zirconium:	
Reactor-grade sponge, per pound [4]	5.00 to 7.00
Reactor-grade ingot and alloy ingot, per pound [4]	6.00 to 8.00
(Commercial grades about $1 per pound less)	
Strip, hot rolled, per pound [5]	11.00 to 15.00
Strip, cold rolled, per pound [5]	13.00 to 18.00
Plate, per pound, nominal [5]	10.00
Bars and rod, forged or hot rolled, per pound, nominal [5]	12.00
Powder, commercial, per pound [6]	10.00
Zirconium compounds (f.o.b. warehouse Jersey City, N.J.), single-drum prices:[4]	
Basic sulfate, per pound of contained ZrO_2	.91
Carbonate, per pound of contained ZrO_2	.945
Hydroxide, per pound of contained ZrO_2	1.00
Oxide, per pound as is	.95
Acetate, per pound as is	.367
K_2ZrF_6, per pound as is	.565
Hafnium:	
Sponge, over 1,000 pound lots, per pound [4]	72.50
Bar and plate, rolled, per pound [6]	120.00

---

[1] Metals Week. V. 39, Nos. 1–53, January-December 1968.
[2] Oil, Paint and Drug Reporter. V. 194, No. 27, Dec. 30, 1968.
[3] Carload lots ½ cent less per pound.
[4] Quoted by a leading producer.
[5] Steel. V. 162, Nos. 1–26, Jan. 1–June 24, 1968; V. 163 Nos. 1–27, July 1–Dec. 30, 1968.
[6] American Metal Market. V. 75, Nos. 1–250, Jan. 2–Dec. 31, 1968.

FOREIGN TRADE

Exports of zirconium ores and concentrates totaling 2,026 tons valued at $360,960 were made to 18 countries with the five major recipients being Canada (33 percent), Colombia (25 percent), Mexico (10 percent), Argentina (9 percent), and Chile (7 percent). The considerable differences in declared values from the average of $178.16 per ton ranged from $62.20 and $81.63 per ton for materials shipped to Bolivia and Canada, respectively, to $369 per ton for a small quantity shipped to Belgium-Luxembourg. Unwrought zirconium and zirconium alloys plus waste and scrap shipped to 10 countries, mainly the United Kingdom, weighed 230,154 pounds valued at $1,083,727. Wrought zirconium and zirconium alloys, shipped mostly to Canada (58 percent), United Kingdom, Sweden, West Germany, and France and to 13 other countries, totaled 463,773 pounds worth $7,624,986. The unit value of the shipments to France was extremely low, indicating the possibility that it may have been scrap or some other low-priced material, but a small quantity shipped to India was high-priced, indicating that it may have been composed all or mostly of specialized forms.

Imports of zircon, 98 percent from Australia, increased 1 percent to 59,900 tons while the unit value increased 5 percent to $33.60 per ton. Shipments of zirconium oxide from four countries but predominantly from the United Kingdom, totaled 257,081 pounds worth $121,591, a 50-percent increase in weight of material but a drop of 30 percent in unit value. A small quantity of a high-priced zirconium oxide again was imported from Switzerland. Other zirconium compounds totaling 2,670,699 pounds valued at $663,383 were imported from the United Kingdom (76 percent), Japan (23 percent), West Germany, the Netherlands, and Canada. The sizable quantity from Japan had a low unit value similar to that of previous years.

Imports of unwrought zirconium and waste and scrap totaling 300,000 pounds and valued at $1,128,378 were received almost exclusively from France with a minute quantity from the United Kingdom. Unwrought alloys from France (82 percent), West Germany (16 percent), and the United Kingdom weighed 22,163 pounds worth $125,601. Wrought zirconium, mostly from Sweden (72 percent) and also from France, Japan, Canada, and the United Kingdom, totaled 11,463 pounds valued at $130,423. Ferrozirconium, totaling 583,082 pounds worth $105,239 came from France (70 percent), Japan (20 percent), and West Germany (10 percent). Unwrought hafnium, apparently mostly waste and scrap from Japan and some more valuable material from West Germany and Belgium-Luxembourg, weighed 169 pounds and was valued at $6,142.

Table 2.—U.S. imports for consumption of zircon, by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Argentina	225	$11	--------	--------	--------	--------
Australia	56,231	1,606	57,908	$1,873	58,812	$1,963
Canada [1]	1,236	26	1,111	13	904	35
Ethiopia	110	3	--------	--------	--------	--------
Malaysia	11	(2)	56	2	--------	--------
Norway	140	5	--------	--------	--------	--------
South Africa, Republic of	--------	--------	--------	--------	28	8
Syrian Arab Republic	--------	--------	228	3	45	3
United Arab Republic	23	1	--------	--------	--------	--------
United Kingdom [1]	--------	--------	--------	--------	111	5
Total	57,976	1,652	59,303	1,891	59,900	2,014

[1] Believed to be country of shipment rather than country of origin.
[2] Less than ½ unit.

WORLD REVIEW

Australia.—New estimates of Australian zircon reserves are shown in the accompanying table, in thousand long tons:[9]

Associated Minerals Consolidated Ltd	1,500
Cable (1956) Ltd [1]	100
Coastal Mining Development Pty. Ltd	80
Consolidated Rutile Ltd	540
Cudgen R.Z. Ltd	640
Mineral Deposits Pty. Ltd	1,230
Murphyores Holdings	1,300
Naracoopa Rutile Ltd	80
Northern Rivers Rutile Pty. Ltd	50
Queensland Titanium Mines Pty. Ltd	400
Rutile and Zircon Mines (Newcastle) Ltd	600
Titanium and Zirconium Industries Pty. Ltd	50
Western Mineral Sands Pty. Ltd.[1]	200
Western Titanium N.L.[1]	550
Westralian Oil Ltd.[1]	350
Total	7,670

[1] West Coast operation.

In March, the Stradbroke Island dredging plant of Associated Minerals Consolidated Ltd. was commissioned. Its mineral sand capacity of 1,200 cubic yards per hour makes this operation the largest of its kind in the world. The company separated heavy minerals at dry plants at

---

[9] Industrial Minerals (London). No. 8, May 1968, pp. 19–22.

Table 3.—Free world production of zirconium concentrates by countries

(Short tons)

Country	1964	1965	1966	1967	1968 ^{p}
Australia	206,173	^{r}254,085	^{r}263,925	330,120	347,099
Brazil	^{r}2,504	^{r}1,818	^{r}2,700	^{p}2,934	3,083
Ceylon	55	40	167	130	28
Korea, South	---------	2,057	90	6	NA
Malagasy Republic	564	710	777	230	---------
Malaysia (zircon exports)	162	629	866	520	1,241
Nigeria	171	---------	NA	NA	NA
Senegal	611	---------	---------	---------	---------
Thailand	---------	---------	---------	1,687	3,549
United Arab Republic	45	---------	429	NA	---------
United States	W	W	W	W	W
Total [1]	^{r}210,285	^{r}259,339	^{r}268,954	335,627	355,000

^{p} Preliminary. ^{r} Revised. NA Not available.
W Withheld to avoid disclosing individual company confidential data.
[1] Total is of listed figures only.

Southport, Queensland, and at Byron Bay, Hexham, and Wyong, New South Wales. At Naracoopa on King Island in Bass Strait, Tasmania, a new company, Naracoopa Rutile Ltd., was building a plant with an annual capacity of 10,000 tons each of zircon and rutile. At this rate zircon reserves would last 8 to 10 years. Murphyores Inc. Pty. Ltd. started mining at Gladstone, Queensland, late in the year with a processing plant for zircon, rutile and ilmenite scheduled to go on stream in early 1969. The operation is described in the Titanium chapter of this volume.

Canada.—It was expected that by January 1969 Eldorado Nuclear Limited, formerly Eldorado Mining & Refining Ltd., would be using a new method to produce directly a zirconium alloy ingot at its new Port Hope, Ontario plant. An initial rate of 200 tons per year will be expanded to 300 tons. The company's "Zingot" (bomb reduction) process will produce 1,000-pound zirconium alloy cylinders which can readily be welded, arc melted, and formed into billets for rolling or tube extrusion.

France.—Ugine-Kuhlmann Company had an annual production capacity of over 700 tons of zirconium sponge, 400 tons of ingot, and the ability to produce plates, strips, bars, and wire.

Japan.—The only firm producing metallic zirconium, the Japan Mining Co., was reported to have a 360-ton-per-year capacity, although domestic demand was much less. Two companies, Kobe Steel Works Ltd., and Sumitomo Metal Industries, Ltd., announced plans to fabricate zirconium products. Kobe planned to complete a 1.3-million-foot-per-year Zircaloy tubing plant at its Chofu Kita works in western Honshu by the end of 1971. Sumitomo completed a pilot plant with a capacity of 50,000 meters of Zircaloy tubing per year in Amagasaki City, Hyogo Prefecture. By 1970, the firm expected to complete a plant south of Biwa Lake, Shiga Prefecture, able to make 500,000 meters of Zircaloy tubing per year.

South Africa, Republic of.—Baddeleyite (zirconium oxide) concentrates were extracted from apatite (phosphate) ores by the Government-controlled Phosphate Development Corp. Ltd. (FOSKOR).

TECHNOLOGY

Although heavy concentrates containing zircon are extracted commercially from beach and stream placers, byproduct recovery from other sources may prove feasible as well as profitable. Studies showed the potential of waste products resulting from the beneficiation of Florida phosphate rock, particularly as a source of zircon, monazite, and ilmenite.[10]

---

[10] Stow, Stephen H. The Heavy Minerals of the Bone Valley Formation and Their Potential Value (Scientific Communications). Econ. Geol., v. 63, No. 8, December 1968, pp. 973–975.

The Bureau of Mines, with industry participation, studied possible means for recovering marketable grade concentrates of zircon, monazite, ilmenite, and rutile from Florida phosphate plant operations. Likewise, the Bureau investigated the economic separation of heavy minerals from sand and gravel operations. Other Bureau metallurgy research in zirconium and hafnium consisted of measuring vapor pressures of molten binary systems, preparing, evaluating, and observing the properties of metal carbide-carbon alloys, and studying the nature of thermal balance in the consumable electrode arc melting of zirconium and hafnium.[11]

Owing to its low thermal neutron cross section and resistance to water and steam corrosion, a constantly growing application of zirconium is as a construction material, particularly as alloys, in nuclear reactors. The creep rates of zirconium alloys, an important consideration in nuclear reactors, were described in several papers.[12] Sometimes in-reactor creep rates are five to ten times as high as out-of-reactor rates with radiation dose, temperature, alloy, heat treatment, and stress as contributing factors.

In chemical processing, zirconium was shown to be more resistant than titanium to caustic alkalies and also very resistant to hydrochloric acid at almost all strengths and temperatures.[13] The passivity of zirconium and titanium is not affected by heat transfer and they were believed to be more efficient than stainless steel in applications such as heat exchangers.[14] For over 3 years the British dye industry has been using small zirconium pressure vessels.

Zirconium hydride is being used in reactors for aerospace activities. The new S8DR flight prototype reactor using the hydride is designed for 10,000 hours of operation at 600 kwt. An advanced design study was made for a 20,000-hour reactor using a thermoelectric conversion system.[15]

Stabilized zirconia has received increased attention in ceramics. Evaluations of the refractory qualities of fused cast zirconia-alumina in blast furnaces were made.[16] A chemically bonded zirconia foam, still in a developmental state, showed promise as a thermal insulation material at 3,000°F; it had low density and thermal conductivity, good thermal shock resistance, high melting point, and good mechanical strength.[17]

Of all the refractory binary compounds, hafnium carbide has the highest melting point, around 3,890° C. Because its potential applications are of interest to the aerospace industry, production by vapor deposition of single-crystal whiskers of hafnium carbide was investigated.[18] Other diboride composites of hafnium, zirconium, and titanium were prepared and evaluated; the best oxidation resistance observed was for a hafnium diboride-silicon carbide composite.[19]

Tests made during the operation of the first core of the Shippingport reactor showed that hafnium was adequate as a long-life neutron absorber because of its additional properties of corrosion and fatigue resistance.[20]

---

[11] Adams, R. P., M. I. Copeland, D. K. Deardorff, and R. L. Lincoln. Cast Hafnium Carbide-Carbon Alloys. Preparation, Evaluation, and Properties. BuMines Rept. of Inv. 7173, June 1968, 50 pp.

Koch, R. K., and W. E. Anable. Vapor Pressures of Liquid Molybdenum (2,890° to 2,990° K) and Liquid Zirconium (2,229° to 2,795° K). BuMines Rept. of Inv. 7063, January 1968, 22 pp.

Koch, R. K., W. E. Anable, and R. A. Beall. Vapor Pressures of Liquid Columbium (2,740° to 3,140° K) and Liquid Hafnium (2,500° to 2,810° K). BuMines Rept. of Inv. 7125, May 1968, 24 pp.

Wood, F. W. A Model for Molten Pools in Arc Melting. BuMines Rept. of Inv. 7151, July 1968, 33 pp.

[12] Fidleris, V. Uniaxial In-Reactor Creep of Zirconium Alloys. J. Nuclear Materials (Amsterdam), v. 26, No. 1, April 1968, pp. 51–76.

Piercy, G. R. Mechanisms for the In-Reactor Creep of Zirconium Alloys. J. Nuclear Materials, v. 26, No. 1, April 1968, pp. 18–50.

[13] Scholes, I. R. The Behavior of Titanium and Zirconium in Industrial Environments. Anti-Corrosion (London), v. 3, No. 1, January 1968, pp. 6–8.

[14] Whitworth, B. H. Titanium and Zirconium in Chemical Plants. Metall (Berlin), v. 22, No. 2, February 1968, pp. 165–166.

[15] Boretz, J. E., and I. R. Jones. Power Systems. Space/Aeronautics, v. 50, No. 2, July 31, 1968, pp. 85–90.

[16] Malim, T. H. (ed.). Less Brick for More Hot Metal. Iron Age, v. 202, No. 15, Oct. 10, 1968, pp. 69–76.

[17] Materials Engineering. V. 67, No. 3, March 1968, p. 45.

[18] Wilcox, W. R., J. R. Teviotdale, and R. A. Corley. Chemical Vapor Deposition of Hafnium Carbide. Trans. Metal Soc. AIME, v. 242, No. 4, April 1968, pp. 588–591.

[19] Clougherty, E. V., R. L. Pober, and L. Kaufman. Synthesis of Oxidation Resistant Metal Diboride Composites. Trans. Metal. Soc. AIME, v. 242, No. 6, June 1968, pp. 1077–1082.

[20] Salvaggio, G. J. Hafnium Control Rod Behavior in the Shippingport Pressurized Water Reactor. Nuclear Applications, v. 5, No. 1, July 1968, pp. 26–34.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-249/181

Minor Metals

By John W. Cole[1] and Richard F. Stevens, Jr.[1]

CONTENTS

	Page		Page
Arsenic	1187	Rhenium	1193
Cesium and rubidium	1189	Scandium	1195
Gallium	1189	Selenium	1196
Germanium	1190	Tellurium	1198
Indium	1191	Thallium	1199
Radium	1191		

ARSENIC[2]

Domestic Production.—Arsenic trioxide was produced domestically only at the Tacoma, Wash., copper smelter of American Smelting and Refining Company, as a byproduct. Source of the arsenic was not only copper ores and concentrates, but also speiss, flue dust, and sludges from other smelting plants that were treated for recovery of arsenic and other metals. Production figures cannot be published, but 1968 sales were substantially less than those of 1967.

Consumption and Uses.—Apparent consumption of arsenic, as measured by imports plus domestic sales, decreased 8 percent. Calcium and lead arsenate chemicals were the major end products; however, significant quantities of sodium arsenate were used in organic herbicides.

Arsenic chemicals were used primarily as pesticides in agriculture for control of rodents, insects, and weeds and as a defoliant to aid in harvesting of certain crops such as cotton which is defoliated prior to mechanical harvesting.

Arsenic metal was used in small quantities in nonferrous alloys of copper and lead. The hard lead used for casting electric storage battery posts and plates is an alloy of lead, antimony, and arsenic. The arsenic content ranges from 0.2 to 0.75 percent. Annual use of hard lead amounts to about 50 percent of the total lead used in batteries, or some 1.5 million tons. Therefore, 3,000 to 11,250 tons of arsenic per year are used for this purpose. Arsenic was also added to lead used in shot casting to increase the sphericity of the shot.

White arsenic was used in glass as a decolorizer and also in opal glass and in enamels. Arsenic compounds were used for parasitic control in stock and poultry feeds. They also were used in chemical reagents such as those used in flotation of minerals and wood preservatives.

Prices.—The price of refined white arsenic, 99.5 percent, at New York docks, in barrels, small lots, was 6 to 6¼ cents per pound throughout the year. Refined white arsenic in bulk carload lots at Laredo, Tex., was $87 per ton, and crude white arsenic remained at $69 per ton at Laredo, Tex., and Tacoma, Wash.

The price of arsenic metal in London increased from £445 to £518 per long ton coincident with the 1967 devaluation of the pound sterling so the equivalent New York price remained 55.6 cents per pound.

The yearend price of lead arsenate in 50-pound bags was 26 cents per pound. Sodium arsenate, 60 percent arsenic pentoxide, in 200-pound drums was quoted at 30 cents per pound; and sodium arsenite, 94 percent soluble pink powder, 75 percent arsenious acid, in 100-pound drums, was quoted at 23 cents per pound.

---

[1] Physical scientist, Division of Mineral Studies.
[2] Prepared by John W. Cole.

Foreign Trade.—U.S. imports of white arsenic declined 7 percent but the value increased 5 percent. The quantity of metallic arsenic imported increased 39 percent to 819,000 pounds and the value increased 94 percent. Imports of arsenic sulfide and sodium arsenate dropped sharply from the levels of imports in 1966–67. Sweden continued to be the major supplier of arsenic metal (99 percent) and white arsenic (36 percent). Mexico and France supplied 28 and 26 percent, respectively, of white arsenic, and the remaining 10 percent was supplied by six other countries.

No exports of arsenic metal or white arsenic were reported. Data were not available on exports of arsenical compounds.

World Review.—Sweden was the world's largest producer of arsenic and largest foreign supplier to the U.S. market. Mexico was second and France third in production. These three countries supplied about 80 percent of world production of white arsenic in 1968.

Table 1.—Consumption of arsenic wood preservatives in the United States

(Short tons)

Year	Consumption of wood preservatives	
	Wolman salts (25 percent sodium arsenate)	Other
1966	2,330	2,256
1967	1,961	2,515
1968 p	1,247	2,775

p Preliminary.

Source: U.S. Forest Service.

Table 2.—U.S. imports for consumption of white arsenic (As_2O_3) content, by countries

Country	1966		1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)	Short tons	Value (thousands)
Belgium-Luxembourg	(1)	(1)	1,107	$160	254	$41
Canada	---------	---------	90	11	8	2
France	4,315	$331	5,557	466	6,424	600
Germany, West	---------	---------	---------	---------	14	3
Japan	---------	---------	---------	---------	199	14
Mexico	11,828	945	11,453	1,017	7,159	716
Peru	---------	---------	18	1	644	52
South Africa, Republic of	6	(1)	968	82	1,134	105
Sweden	2,526	201	6,245	616	9,315	1,090
U.S.S.R	---------	---------	1,626	149	44	3
United Kingdom	---------	---------	11	1	---------	---------
Total	18,675	1,477	27,075	2,503	25,195	2,626

[1] Less than ½ unit.

Table 3.—U.S. imports for consumption of arsenicals, by classes

(Thousand pounds and thousand dollars)

Class	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
White arsenic As_2O_3)	37,350	$1,477	54,149	$2,503	50,390	$2,626
Metallic arsenic	362	194	590	301	819	583
Sulfide	60	5	578	35	50	12
Sheepdip	------	--------	10	2	--------	--------
Calcium arsenate	200	3	--------	--------	--------	--------
Sodium arsenate	364	31	253	22	75	6

Table 4.—World production of white arsenic (arsenic trioxide), by countries[1] [2]

(Short tons)

Country	1964	1965	1966	1967	1968 [p]
Brazil	207	282	[r] 352	245	344
Canada	162	202	351	378	346
France	[r] 12,509	[r] 13,371	13,220	15,588	15,000
Germany, West	NA	NA	[r] 1,090	583	882
Japan	550	528	603	709	756
Mexico	[r] 16,256	[r] 15,183	17,311	16,498	14,915
Peru	685	550	402	298	1,352
Portugal	410	[r] 205	[r] 214	278	220
Rhodesia, Southern	206	[e] 70	NA	NA	NA
Spain	158	131	123	142	143
Sweden	19,809	18,188	16,204	22,266	23,210
U.S.S.R.[e]	7,200	7,500	7,600	7,716	7,716
United States	W	W	W	W	W
Total [3]	[r] 58,152	[r] 56,210	[r] 57,470	64,701	64,884

[e] Estimate. [p] Preliminary. [r] Revised. NA Not available. W Withheld to avoid disclosing individual company confidential data.

[1] Arsenic may be produced in Argentina, Austria, Belgium, China (mainland), Czechoslovakia, East Germany, Finland, Hungary, Territory of South-West Africa, United Kingdom, and Yugoslavia, but there is too little information to estimate production.

[2] Including calculated trioxide equivalent for output reported as elemental arsenic and arsenic compounds.

[3] Total is of listed figures only.

CESIUM AND RUBIDIUM[3]

Domestic Production.—The source of all cesium and rubidium produced in the United States in 1968 was imported pollucite and ALKARB, a residue from past lithium production.

Cesium and rubidium compounds and rubidium metal were produced by Penn Rare Metals Division of Kawecki-Berylco Industries, Inc., Revere, Pa. The only cesium metal produced was 1 pound by a research company. The American Potash & Chemical Corp. consumed a small quantity of cesium compounds and supplied their customers with cesium compounds from stocks. The Dow Chemical Co. shipped cesium metal from stocks.

Consumption and Uses.—Statistical data on the consumption and uses of cesium and rubidium compounds were not available.

Various forms of cesium had applications in photomultiplier tubes, infrared lamps, scintillators, counters, and spectrophotometers.

Pollucite consumption was small and none was imported during the year.

Prices.—Prices of cesium and rubidium metal and compounds were unchanged from those of the previous year.

Foreign Trade.—Imports of cesium chloride, principally from West Germany, amounted to 1,159 pounds valued at $45,000. Imports of other cesium compounds, also principally from West Germany, amounted to 1,958 pounds valued at $66,162.

Imports of rubidium amounted to 81 pounds valued at $2,063, all from Canada.

Imports of pollucite, cesium metal, and rubidium compounds and exports of cesium and rubidium and their compounds are not classified separately by the Bureau of the Census and are available only by special request.

GALLIUM[4]

Domestic Production.—Gallium metal was produced by the Aluminum Company of America at its Bauxite, Ark., plant as a byproduct of alumina production. Gallium metal, oxide, and trichloride were produced by Eagle-Picher Industries, Inc. at its Quapaw, Okla., plant as a byproduct of production of zinc from sphalerite.

Consumption and Uses.—The largest single use of gallium was reportedly in green phosphors used in phosphorescent tubes such as the activating tubes in duplicating machines using the xerography process. Gallium is used in semiconductor alloys of the Groups III–V type where it usually is alloyed with arsenic or phosphorus. A smaller quantity was used in doping germanium crystals used in radiation detection devices. Minor uses of the metal were in high-temperature thermometers, sealant for glass joints, as a constitutent of solders and in research.

---

[3] Prepared by John W. Cole.

[4] Prepared by John W. Cole.

Prices.—Market prices, per gram, of gallium from bauxite sources were unchanged from those of 1967 and were as follows:

Quantity	99.99 percent	99.999 percent	99.9999 percent
Up to 999 grams	$1.40	$1.50	$1.70
1,000 to 4,999 grams	1.20	1.30	1.50
5,000 to 24,999 grams	1.10	1.15	1.35
Over 25,000 grams	.95	1.00	1.20

It was reported that gallium was being offered by producers at discounts as high as 35 percent under quoted prices.

Foreign Trade.—Imports of gallium (unwrought, waste and scrap) as reported by the Bureau of the Census were as follows:

Country of origin	Pounds	Value
Japan	24	$9,307
Switzerland	12,255	368,593
United Kingdom	65	5,861
West Germany	16	2,152
Total	12,360	385,913

The quantity of imports from Switzerland in December appeared to be exceptionally high. Either the material was very low grade or there was an error in reporting.

GERMANIUM [5]

Domestic Production.—Primary germanium output was derived from smelter residues resulting from retorting and refining of zinc concentrates from the Kansas-Oklahoma area and from fluorspar-zinc-lead ores of the Kentucky-Illinois area. Eagle-Picher Industries, Inc., operated a refinery at Miami, Okla.

Kawecki-Berylco Industries, Inc., Revere, Pa., and Sylvania Electric Products, Inc., Towanda, Pa., operated refineries principally to reprocess domestic scrap supplemented by imports of germanium dioxide and scrap.

Consumption and Uses.—The principal domestic market for germanium still was in transistors and semiconductor diodes. Although the use of silicon is growing, the use of germanium is expected to continue at the present levels. Factory shipments of transistors and semiconductor diodes were up 16 percent and 21 percent, respectively, from those of 1967. Shipments of germanium transistors, however, were down 26 percent; shipments of germanium semiconductor diodes were about the same as in 1967.

Significant quantities of single crystal, gallium-doped germanium were used in production of radiation detectors. This is expected to become a rapid-growth use of the metal.

Although not used domestically, germanium catalysts have gained extensive use in Japan and Europe in textile (polyester) manufacture.

Prices.—Prices for germanium and germanium dioxide remained firm throughout the year. The price of purified ingot was $175.25 per kilogram, and the price of electronic grade germanium dioxide was $88.40 per kilogram. Gallium-doped single crystal germanium was reported to have been sold at $1 to $1.50 per gram.

Foreign Trade.—U.S. imports of germanium, germanium dioxide, and scrap inrceased 21 percent in quantity to 4,100 pounds, and 61 percent in value to $430,000. Included were over 700 pounds of material from Belgium-Luxembourg valued at $450 per pound, 5 to 6 times the value of intrinsic ingot. Imports are tabulated as follows:

---

[5] Prepared by John W. Cole.

Country of origin	Pounds	Value
	Unwrought, and waste and scrap	
Belgium-Luxembourg	818	$340,448
Germany, West	714	19,792
Italy	995	26,595
United Kingdom	1,543	31,883
Total	4,070	418,718
	Wrought	
Belgium-Luxembourg	32	11,317
Germany, West	1	416
Total	33	11,733

World Review.—The major foreign producer of germanium was the Société Générale Métallurgique de Hoboken, utilizing base metal ores and concentrates imported from African mines. Germanium was also produced from imported materials in West Germany, United Kingdom, Italy, and Japan.

INDIUM[6]

Domestic Production.—The American Smelting and Refining Company produced indium metal and chloride at its Perth Amboy, N.J., plant and indium metal at its Denver, Colo., plant. The Anaconda Company produced 85,640 troy ounces of indium at its Great Falls, Mont., plant compared with 61,000 ounces in 1967. Source material for indium was certain smelter flue dusts and residues in which the trace quantities of indium in zinc minerals were concentrated.

Uses.—Indium was used in electronic devices in a variety of ways, such as a component of solder for connecting lead wires to germanium in transistors, and as a property-modifying component of the intermetallic germanium semiconductor. The compounds, indium arsenide, indium antimonide, and indium phosphide were also used in semiconductor applications.

Stocks.—Producer stocks of indium increased substantially during the year.

Prices.—The market quotations for indium at the beginning of the year were $2.75 per troy ounce for 30 to 90 ounces in stick shapes: ingots were $2.30 per troy ounce in 100-ounce lots and $2 in plus 10,000-ounce lots. All quotations were lowered $0.25 per ounce September 19 and remained the same at yearend. The lower prices were caused by increased imports, particularly from Japan.

Foreign Trade.—Imports for consumption of indium (unwrought, waste and scrap) totaled 280,421 troy ounces valued at $484,528, a slight decrease from 1967 levels both in quantity and value. Canada supplied 183,642 ounces ($308,631), down 33 percent from 1967 imports. Japan supplied 51,235 ounces ($113,949), up from less than 1,000 ounces in 1967, the first year in which imports of indium were recorded from Japan. West Germany supplied 14,684 ounces ($18,246), and 13,327 ounces ($16,109) was imported from the U.S.S.R. The remainder was supplied by Peru, United Kingdom, Netherlands, and Belgium-Luxembourg.

A total of 636 ounces of wrought indium was imported, principally from Japan.

RADIUM[7]

Domestic Production.—As in former years no primary radium was produced in the United States but Radium Chemical Co. Inc. New York, continued to offer radium salts recovered from Congolese (Kinshasa) ores by the Belgian company Union Minière du Haut-Katanga. Other domestic firms which handled radium materials, primarily radium salts, during 1968 were United States Radium Corp., Morristown, N.J.; and Canadian Radium & Uranium Division, Canrad Precision Industries, Inc., New York. Radioactive isotopes (radioisotopes) were the primary interest of both of these companies and radium continued to represent only a relatively minor share of their business.

---

[6] Prepared by John W. Cole.

[7] Prepared by Richard F. Stevens, Jr.

Table 5.—U.S. exports of domestic cobalt-60, radium, and other radioisotopes, by major country

Country of destination	1967[1] Millicuries	1967[1] Value (thousands)
Cobalt-60:		
Belgium	7,581,000	$42
Brazil	20,000	1
Canada	7,954,000	43
Columbia	1,836,000	11
Israel	11,609,000	66
Japan	15,881,200	132
Korea, South	2,735,000	15
Mexico	4,000	(2)
Philippines	30,000	1
Taiwan	520	4
Total	47,650,720	315
Radium, its salts and compounds:		
Argentina	39	1
Belgium	12,065	178
Brazil	20	(2)
Canada	950	15
Ecuador	90	3
Iran	10	(2)
Mexico	20	(2)
Netherlands	30	1
Spain	29	2
United Kingdom	549	4
Venezuela	90	3
Yugoslavia	26	(2)
Total	13,918	207
Other radioisotopes [3]	298,283,056	2,370
Total exports—all domestic radioisotopes	345,947,694	2,892

[1] Data for 1968 not available.

[2] Less than ½ unit.

[3] Includes americium-241, calcium-47, carbon-14, cesium-137, cobalt-57, hydrogen-3, iodine-125, iodine-131, iridium-192, iron-59, molybdenum-99, nickel-63, phosphorus-32, strontium-85, strontium-90, technetium-99, zinc-65, and isotopes not separately identified.

Table 6.—U.S. exports of foreign cobalt-60, radium, and other radioisotopes, by major country

Country of destination	1967[1] Millicuries	1967[1] Value (thousands)
Cobalt-60: Canada	10,150,000	$31
Radium, its salts and compounds: Canada	527	10
Other radioisotopes:		
Canada	5,000,000	10
Total exports—all foreign radioisotopes	15,150,527	51

[1] Data for 1968 not available.

Uses.—Because of the penetrative power of its gamma radiation the major use of radium continued to be in therapeutic treatment of cancer even though the use of the man-made radioisotope cobalt-60 in this application grew significantly during the year and may eventually replace radium completely. Other gamma-producing radioisotope substitutes for radium in medical treatment included cesium-137, iridium-192, and gold-198. Radium used in medical applications may be returned to laboratories for conversion or to be changed from one container to another after being purchased and used by physicians or hospitals. Radium for these uses continued to be available on a lease or rental basis.

Use of radium in luminous paints for instruments, clocks, and watches was almost completely replaced by the radioisotopes krypton-85 and tritium (hydrogen-3) which are less expensive, produce brighter luminescence, and are safer since they emit few or no high energy gamma rays. Neutron sources of radium-beryllium in the 300- to 600-millicurie range are being replaced by sources which have no associated gamma radiation such as plutonium-beryllium.

Because radioisotopes have been developed which are less expensive and more efficient than radium, the demand for this material has decreased substantially. As a result, plans are being made to dispose of most of the excess radium salts in such a way that the public will be protected from the gamma radiation which is emitted from radium materials.

World Review.—Because radium is currently recovered primarily from the residues resulting from uranium milling operations, no specific figures are available on world production.

Belgium.—Union Minière du Haut-Katanga, through its subsidiary company Metalurgie Hoboken S.A., operated a uranium ore refinery at Olen. Radium recovered from the resulting uranium sludges was used as the starting material for the preparation of the radioisotopes actinium-227 (Ac^{227}) and thorium-228 (Th^{228}) by neutron irradiation. The use of radium by Hoboken at the Olen plant will reach an industrial scale as a result of the announced plans for full-scale production of Ac^{227} in 1969.

Table 7.—U.S. imports of radium, cobalt-60, and other radioisotopes, by major country

Country of destination	1966		1967		1968	
	Millicuries	Value (thousands)	Millicuries	Value (thousands)	Millicuries	Value (thousands)
Cobalt-60:						
Canada	197,455,000	$791	379,575,000	$1,005	807,789,000	$1,390
United Kingdom	88,000	17	----------	-----	----------	-----
Subtotal	197,543,000	808	379,575,000	1,005	807,789,000	1,390
Radium, its salts and compounds:						
Belgium	NA	NA	5,274	73	NA	NA
Canada	NA	NA	538	14	NA	NA
United Kingdom	NA	NA	677	8	NA	NA
Subtotal	NA	NA	6,489	95	NA	NA
Other radioisotopes [1]	NA	NA	49,910,853	1,877	NA	NA
Total imports—all radioisotopes	[2] 197,543,000	[2] 808	429,498,831	3,072	[2] 807,789,000	[2] 1,390

NA Not available.

[1] Includes carbon-14, iodine-128, iodine-131, iridium-192, phosphorus-32, sodium-22, strontium-85, sulfur-35, and isotopes not separately identified.

[2] Represents cobalt-60 imports only.

RHENIUM [8]

The demand for rhenium in high-temperature tungsten-rhenium and molybdenum-rhenium alloys decreased as the research contracts on alloy development and properties sponsored by the Atomic Energy Commission (AEC) were successfully completed. This decline was partially offset by the development and use of rhenium and rhenium-platinum catalysts in the petroleum industry. It has been estimated that rhenium demand, primarily in these applications, could total about 20,000 pounds annually by 1972.

Domestic Production.—Production of rhenium, a secondary byproduct recovered from the molybdenite (MoS_2) associated with Southwestern porphyry copper ores, increased during 1968 to some 2,400 pounds of rhenium contained in rhenium salts. Cleveland Refractory Metals (CRM), Solon, Ohio, a division of Chase Brass & Copper Co. (a subsidiary of Kennecott Copper Corp.) remained the only domestic producer of rhenium metal powder during the year. Rhenium salts were recovered for CRM at Kennecott's molybdenite roasting facility near Garfield, Utah, following settlement of the copper strike early in the year. Shattuck Chemical Co., Denver, Colo., also recovered rhenium salts for CRM. In addition, Shattuck reportedly processed some rhenium-bearing material of foreign origin.

Porphyry copper deposits in Chile, Congo (Kinshasa), the United States, and the U.S.S.R. represented the only significant sources of rhenium. Rhenium metal was recovered at roasting plants in Belgium, the Soviet Union, the United Kingdom, the United States, and West Germany.

---

[8] Prepared by Richard F. Stevens, Jr.

Table 8.—Rhenium statistics

(Pounds of contained rhenium)

	1964	1965	1966	1967	1968
Production (in rhenium salts) [e]	1,000	1,200	1,620	1,725	2,400
Consumption (metal) [e]	1,500	1,010	1,040	850	775
Imports (metal)	212	469	84	96	436
Stocks (metal) (December 31) [e]	560	620	600	40	130

[e] Estimate.

Consumption and Uses.—Approximately 775 pounds of rhenium metal powder was consumed during the year, down 9 percent from that of 1967. Although a significant amount of this consumption was in high-temperature, high-strength tungsten-rhenium (W-Re), tungsten-molybdenum-rhenium (W-Mo-Re), and molybdenum-rhenium (Mo-Re) alloys, usage in these applications decreasd during the year as AEC-sponsored alloy development and evaluation work was completed. This decrease was partially offset by the development of rhenium and rhenium-platinum catalysts as replacements for more expensive platinum catalysts used in the cracking of petroleum hydrocarbons. Other applications continued to be in electrical contacts, flashbulb filaments, heating elements, and coatings.[9] It was estimated that about 65 percent of total rhenium consumption was in the form of high-temperature refractory metal alloys, about 15 percent was in the form of catalysts, and about 20 percent was consumed in other applications.

The relative percentage of rhenium consumed as catalysts will increase substantially in future years and is expected to account for more than half of the anticipated market of 20,000 pounds per year foreseen by CRM in 1972.[10] To pave the way for this growth, CRM increased its rhenium processing capacity to 8,000 pounds per year.

A report on the use of rhenium was released during the year which discussed the availability and use patterns for this metal.[11]

Prices.—During the year Cleveland Refractory Metals (CRM) continued to quote the following prices for rhenium materials, minimum order $50:

	Per pound
Ammonium perrhenate (NH_2ReO_2), up to 5 pounds	$425
Ammonium perrhenate, over 5 pounds	$400
Potassium perrhenate ($KReO_2$), up to 5 pounds	$395
Potassium perrhenate, over 5 pounds	$370
Rhenium metal, grade I, up to 1 pound	$650
Rhenium metal, grade I, 20 or more pounds	$580
Rhenium sintered bar (melting stock), up to 1 pound	$800
Rhenium sintered bar (melting stock), 5 or more pounds	$750
Rhenium rod stock, 0.2 inch in diameter	$900
Rhenium rod stock, 0.025 inch in diameter	$1,260
Rhenium strip, 0.6 inch thick	$815
Rhenium strip, 0.001 inch thick	$1,580

Rhenium metal powder continued to be available at about $500 per pound when credit for returned rhenium alloy scrap was allowed. CRM, using special patented processes, recycled this scrap material to recover the rhenium content. High-purity rhenium metal was produced from a mixture of rhenium salts and rhenium scrap starting materials.

Foreign Trade.—Imports of high-purity rhenium metal powder increased by a factor of over four during the year to 436 pounds, rhenium content, valued at $149,208. This significant increase, almost entirely from West Germany, approached the import level of 1965. Imported rhenium metal powder continued to be sold for approximately $20 per pound less than comparable domestic rhenium despite the duty (9 percent ad valorem) paid. There were no imports of wrought rhenium during the year.

As part of the 5-year program of tariff reductions agreed upon at the Kennedy Round Tariff Negotiations, the duties on unwrought and wrought rhenium were further reduced. Effective January 1, 1969, the duty on unwrought rhenium was reduced from 9 percent to 8 percent ad valorem, and that for wrought rhenium from 16 to 14 percent.

Technology.—Deposition studies were reported which indicated that coherent, high-purity rhenium deposits could be obtained by the hydrogen reduction of rhenium hexafluoride (ReF_6) from the vapor phase.[12] A technical progress review of rhenium alloy development, fabrication techniques, oxidation and corrosion resistance, and mechanical properties was conducted for the AEC with special emphasis on high-temperature reactor material application.[13]

---

[9] Spelman, Jon W. Where Rhenium Is Growing. Metal Prog., v. 93, No. 2, February 1968, pp. 103–114.

[10] Chemical Week. Rhenium's Big Chance. V. 103, No. 12, Sept. 21, 1968, p. 67.

[11] National Research Council. Trends in Usage of Rhenium—A Report by the Materials Advisory Board. MAB–251, National Academy of Sciences/National Academy of Engineering, Washington, D.C., December 1968, 9 pp.

[12] Donaldson, J. G., F. W. Hoertel, and A. A. Cochran. Preliminary Study of Vapor Deposition of Rhenium and Rhenium-Tungsten. J. Less-Common Metals, v. 14, No. 1, January 1968, pp. 93–101.

[13] Simons, E. M., S. W. Porembka, Jr., and D. L. Keller. Reactor Materials. Battelle Memorial Inst., Columbus, Ohio, v. 11, Nos. 1–4, 1968, 283 pp.

Table 9.—U.S. imports for consumption of rhenium, by countries

Country	1964		1965		1966		1967		1968	
	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value	Pounds	Value
France	------	------	5	$2,624	------	------	23	$10,206	17	$6,722
Germany, West	208	$94,033	460	208,523	84	$37,371	72	31,142	419	142,217
United Kingdom	4	3,374	4	1,938	------	------	1	1,164	(1)	269
Total	212	97,407	469	213,085	84	37,371	96	42,512	436	149,208

[1] Less than ½ unit.

The development and evaluation of rhenium and rhenium-platinum catalysts received considerable attention because of the potentially large rhenium usage which could result.[14]

Several significant patents were granted covering the recovery of rhenium from scrap, rhenium extractive metallurgy, and rhenium alloy preparation.[15]

Studies on tungsten-technetium (W–Tc) alloys indicated that alloys of the W–Tc system, like those of the tungsten-rhenium (W–Re) system, had a ductilizing effect.[16]

As part of the evaluation of technetium as a replacement for rhenium in tungsten alloys, the W–Tc phase diagram was studied.[17]

As a result of preliminary studies conducted on the separation of palladium, rhodium, and technetium from fission waste products,[18] the AEC requested expressions of commercial interest from the domestic industry for the recovery of these materials from waste fission products generated in the Hanford (Washington) reactors.[19]

SCANDIUM [20]

Domestic Production.—During the year scandium was recovered in small quantities from imported Norwegian thortveitite and euxenite and from sludges recovered from uranium and tungsten processing operations. The principal domestic scandium producers, refiners, or dealers in 1968 were Alfa Inorganics, Inc., Beverly, Mass.; Atomergic Chemetals Co., Division of Gallard-Schlesinger Chemical Manufacturing Corp., Carle Place, N.Y.; King Products, Inc., Arlington, N.J.; Research Chemicals, Division of Nuclear Corporation of America, Phoenix, Ariz.; Semi-Alloys, Inc., Mount Vernon, N.Y.; and Semi-Elements, Inc., Saxonburg, Pa.

Since most uranium ores contain trace quantities of scandium, it is possible to recover the scandium by first allowing it to accumulate in the organic solvent used in uranium solvent extraction. To be reused in the uranium circuit, this organic solvent must be periodically purified at which time the resulting sludge is recovered and treated for its scandium content (approximately 0.10 percent).

---

[14] Corrigan, Mary H., William H. Davenport, and Jon W. Spelman. A Bibliography on the Catalytic Applications of Rhenium (1930–1967). Cleveland Refractory Metals, Solon, Ohio, 1968, 64 pp.

Davenport, William H., Valerie Kollonitsch, and Charles H. Kline. Advances in Rhenium Catalysts. Ind. and Eng. Chem., v. 60, No. 11, November 1968, pp. 10–19.

Kluksdahl, Harris E. (assigned to Chevron Research Co., San Francisco, Calif.). Reforming a Sulfur-Free Naphtha With a Platinum–Rhenium Catalyst. U.S. Pat. 3,415,737, Dec. 10, 1968.

[15] Davenport, William H. (assigned to Chase Brass & Copper Co., Inc., Cleveland, Ohio). Method of Recovering Rhenium Values From Rhenium-Containing Scrap Material. U.S. Pat. 3,407,127, Oct. 22, 1968.

Peters, John E. (assigned to Chase Brass & Copper Co., Inc., Cleveland, Ohio). Process for Preparing Rhenium Refractory Alloys. U.S. Pat. 3,375,109, Mar. 26, 1968.

Zimmerly, Stuart R., and Martin E. Messner (assigned to Kennecott Copper Corp., New York). Extraction of Rhenium and Production of Molybic Oxide From Sulfide Ore Materials. U.S. Pat. 3,376,104, Apr. 2, 1968.

[16] Nelson, R. F., and D. P. O'Keefe. Concluding Progress Report—A Study of Tungsten-Technetium Alloys–October 1, 1966–August 1, 1968. Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., BNWL-865, September 1968, 53 pp.

[17] Johnson, Roger Niles. Solid–Liquid Phase Equilibria in the Tungsten-Technetium Alloy System. M.S. Thesis, Washington State Univ., Pullman, Wash., 1968, 66 pp.

[18] Panesko, J. V. Quarterly Report—Development Program for Recovery of Palladium, Rhodium, and Technetium (MFC-8). Atlantic Richfield Hanford Co., Richland, Wash., ARH-461, Apr. 1, 1968, 22 pp.; ARH-644, June 28, 1968, 14 pp.

[19] U.S. Atomic Energy Commission. Press Release L-252, Oct. 31, 1968, 2 pp.

[20] Prepared by Richard F. Stevens, Jr.

Production of both scandium metal and scandium compounds increased during the year but continued to remain small as most of the material in industrial transactions came from accumulated stocks.

Uses.—Although scandium demand increased during the year, the major requirement for scandium metal and compounds continued to be primarily for use in laboratory scale experimental work. While several producers offered scandium in pound lots, most consumption was measured in quantities of a few hundred grams. The greatest demand for scandium was from university and other groups which were engaged in government research projects studying the physical, mechanical, and radionuclear properties of scandium, its alloys, compounds, and isotopes.

Prices.—Because of variations in purity and quantity the price of scandium and scandium compounds continued to cover a wide range during 1968. Owing to the low volume of business and lack of standard specifications, almost all orders were conducted on a custom basis.

The following prices were quoted for scandium material during the year:

	Per gram
Scandium metal, ingot form, in 10-gram lots	$32.00
Scandium metal, foil, 60 mils (0.060 inch) thick	$23.00
Scandium metal, foil, 5 to 10 mils thick	$75.00
Scandium oxide, 99.9 percent purity, 25-gram to 1-pound lots	$2.80 to $5.00
Scandium salts, anhydrous—chloride, nitrate, sulfate, oxalate, and acetate —over 100 grams	$6.50 to $7.50
Scandium salts, hydrous—chloride, nitrate, sulfate, oxalate, and acetate —over 100 grams	$5.00 to $6.50
Scandium compounds—selenide or telluride	$50.00

In addition, scandium-46, a radionuclide, was offered as the chloride in a hydrochloric acid solution having a specific activity of 10 curies per gram, at $20 per millicurie decreasing to $35 for 10 millicuries.

Technology.—Interest in scandium was indicated by the number of items indexed in Nuclear Science Abstracts[21] which rose 20 percent to 346 items in 1968. Of this total, 142 concerned scandium isotopes, 135 reviewed the chemistry, mechanical properties and extractive metallurgy of scandium metal, 43 evaluated the properties of scandium compounds, and 19 reviewed the preparation and properties of scandium alloys.

A study of the phase diagram of the Ni-Al-Sc system conducted for the U.S. Air Force identified two unknown binary Sc-Ni compounds (Sc_2Ni_7 and $ScNi_5$), one ternary phase ($AlScNi_2$), and the Sc solid solubility limits in Ni, NiAl, and Ni_3Al.[22]

SELENIUM [23]

Although strikes in the copper industry continued to depress production of selenium during the first half of 1968, increased output during the last half raised the year's total selenium production to a level comparable with 1966 and 1967 levels. Shipments and imports of selenium were at record levels.

The Government inventory of selenium was increased by the addition of 49,035 pounds to the Commodity Credit Corporation stockpile inventory during the first half of the year, (27,000 pounds from Canada and 22,035 pounds from Japan) thus raising the inventory up to the objective of 475,000 pounds. At yearend the inventory amounted to 97,100 pounds in the national stockpile and 377,674 pounds in the supplemental stockpile for a total of 474,774 pounds.

Domestic Production.—Of the five plants in the United States reporting production of selenium, four were situated at major electrolytic refineries as follows: American

---

[21] U.S. Atomic Energy Commission. Nuclear Science Abstracts. V. 22, Nos. 1–24, 1968.

[22] Goebel, J. A., and S. Rosen. Phase Equilibria in the Nickel-Aluminum-Scandium System at 1,000° C. J. Less-Common Metals, v. 16, No. 4, December 1968, pp. 441–446.

[23] Prepared by John W. Cole.

Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Co., Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; and Kennecott Copper Corp., Garfield, Utah. The fifth producer, Kawecki-Berylco Industries, Inc., Boyertown, Pa., produces selenium from purchased material from primary and secondary sources. Phelps Dodge Refining Corp., Maspeth, N.Y., sells a crude selenium product to other companies for refining.

Consumption and Uses.—Demand for selenium was strong throughout the year. About one-third of the selenium consumed was used in the glass industry as a decolorizer and also, in larger percentages, to impart tints and colors from dark shades to ruby red. About one-quarter of the total was used in power distribution and specialty transformers and in electronic devices.

Another one-third was used about equally in duplicating machines and inorganic pigments. The remainder was used in steel, rubber, dandruff-suppressing preparations, explosives, and agriculture. Shipments to consumers plus imports (apparent consumption) were higher than in any previous year and increased more than 50 percent from 1967 levels.

Stocks.—Stocks were reduced significantly during the year to a yearend total of about one-half of annual shipments.

Prices.—Selenium prices remained steady at $4.50 per pound for commercial grade and $6 per pound for the high-purity grade.

Foreign Trade.—Of the total imports, Canada supplied 88 percent, Japan supplied 7 percent, Norway supplied 4 percent and the remainder came from West Germany and the United Kingdom.

World Review.—The estimated world production of selenium was about the same as in 1966 and 1967. Canada was the largest producer with the United States a close second and Japan third. These three countries accounted for 85 percent of the production.

Technology.—More than 2,000 articles on selenium and tellurium were abstracted by the American Chemical Society for the Selenium-Tellurium Development Association. Many of the articles describe experiments that add to the evidence that selenium may be an important trace element in animal feed.

Research by manufacturers of duplicating machines was directed toward discovering more versatile mediums than amorphous selenium. Amorphous selenium crystallizes at rather low temperatures and looses its effectiveness.

Table 10.—Salient selenium statistics

(Thousand pounds of contained selenium)

	1964	1965	1966	1967	1968
United States:					
Production	929	540	620	598	633
Shipments to consumers	646	824	845	659	941
Imports for consumption	293	251	286	301	583
Stocks, Dec. 31, producers	1,305	1,021	797	736	428
Price per pound, commercial grade	$4.50–$6	$4.50–$6	$4.50–$6	$4.50–$6	$4.50–$6
World: Production	[r] 2,162	1,799	[r] 1,973	[r] 2,118	2,045

[r] Revised.

Table 11.—World production of selenium by countries[1]

(Thousand pounds of contained selenium)

Country	1964	1965	1966	1967	1968 [p]
Australia [e]	4	5	4	4	4
Belgium-Luxembourg (exports)	87	93	91	90	54
Canada	466	512	575	752	708
Finland	15	13	12	15	[e] 15
Japan	326	348	421	422	394
Mexico	7	18	4	-------	2
Peru	17	19	13	11	13
Sweden	181	176	[r] 154	[r] 158	[e] 154
United States	929	540	620	598	633
Yugoslavia	8	17	21	[r] 10	10
Zambia [2]	122	58	[e] 58	[e] 58	[e] 58
Total [3]	[r] 2,162	1,799	[r] 1,973	[r] 2,118	2,045

[e] Estimate. [p] Preliminary. [r] Revised.

[1] Compiled mostly from data available May 1969.

[2] Contained in copper refinery slimes exported for treatment.

[3] Total is of listed figures only.

TELLURIUM[24]

Domestic Production.—Production of tellurium during 1968 was reported by the following companies: American Metal Climax, Inc., Carteret, N.J.; American Smelting and Refining Company, Baltimore, Md.; International Smelting & Refining Co., Perth Amboy, N.J.; United States Smelting Lead Refinery, Inc., East Chicago, Ind.; and Kawecki-Berylco Industries, Inc,; Boyertown, Pa. Phelps Dodge Refining Corp., Maspeth, N.Y., sells a crude tellurium product to other refineries.

Consumption and Uses.—About 55 percent of the total tellurium consumed was used in steel to improve machinability; 15 percent was used in copper alloys and 10 percent was used in cast iron to control the crystallization of carbon; the remaining 20 percent was used in rubber, as catalysts in chemical processes, and in explosives.

Foreign Trade.—U.S. exports of tellurium are not classified separately by the Bureau of the Census and are available only by special request.

Imports of tellurium totaled 70,600 pounds valued at $404,000. Canada supplied 40,600 pounds and the remainder was imported from Peru. Eleven pounds of tellurium compounds valued at $256 was imported from West Germany.

World Review.—The United States produced about 45 percent of the free world production of tellurium, Canada was second and Peru was third. Since tellurium and selenium are byproducts of the electrolytic refining of copper, probably such large copper producers as Chile and Zambia export crude selenium-tellurium containing slimes to other countries for refining.

Technology.—Tellurium was alloyed with sulfur and germanium to form a glass that has excellent optical properties in the

Table 12.—Salient tellurium statistics

(Thousand pounds of contained tellurium)

	1964	1965	1966	1967	1968
United States:					
Production, primary and secondary	145	195	199	185	121
Shipments to consumers	122	146	215	172	201
Stocks, Dec. 31, producers	162	212	195	186	157
Imports	6	18	18	91	71
Price per pound, commercial grade	$6	$6	$6	$6	$6
World: Production	278	321	334	284	270

---

[24] Prepared by John W. Cole.

infrared region,[25] and superior physical properties such as mechanical strength and higher thermal stability. The glass, which contains 40 percent germanium, 53 percent sulfur, and 7 percent tellurium, is especially useful in the field of detector systems.

Table 13.—Free world production of tellurium by countries [1]

(Thousand pounds of contained tellurium)

Country [2]	1964	1965	1966	1967	1968 p
Canada	78	70	72	82	65
Japan	8	20	23	30	31
Peru	47	36	40	37	53
United States	145	195	199	135	121
Total [3]	278	321	334	284	270

p Preliminary.
[1] Compiled mostly from data available May 1969.
[2] Small quantity also recovered in Australia by Electrolytic Refining and Smelting Co. of Australia Pty. Ltd.
[3] Total is of listed figures only.

THALLIUM [26]

Domestic Production.—American Smelting and Refining Company produced thallium and thallium compounds at its Denver, Colo., plant. It was the first year since 1964 that thallium metal was produced. Shipments of thallium and thallium compounds increased substantially over those of 1967.

Uses.—Thallium was used in pesticide preparations, electronic components, solders, fusible alloys, and other minor applications.

Price.—The quoted price for thallium metal in less-than-100-pound lots was $7.50 per pound.

Foreign Trade.—Imports for consumption of thallium (unwrought (except alloys), waste, and scrap) consisted of 141 pounds, valued at $1,253, from Belgium.

---

[25] Brau, Maurice J. (assigned to Texas Instruments, Inc.). Germanium-Sulfur-Tellurium Glass Compositions and Infrared Detection Systems. U.S. Pat. 3,371,211, Feb. 27, 1968.
[26] Prepared by John W. Cole.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—392-738/21

Minor Nonmetals

By Benjamin Petkof [1]

CONTENTS

	Page		Page
Greensand	1201	Quartz crystal	1206
Iodine	1201	Staurolite	1207
Lithium	1203	Strontium	1207
Meerschaum	1205	Wollastonite	1208

GREENSAND

Domestic production of greensand (glauconite) increased almost 4 percent in quantity and declined 1 percent in value compared with that of 1967. The average annual production for 1964–68 was 3,023 short tons valued at $185,000. Soil conditioning and water softening were the uses for which this material was marketed.

As in 1967 only two firms, Kaylorite Corp. of Maryland and Iversand Co. of New Jersey, produced greensand. Information on production and sales for 1968 is withheld to avoid disclosing individual company confidential data.

IODINE [2]

The Nation's growing demand for iodine was met by a substantial increase in imports of crude iodine and a lesser increase in the domestic output. Consumption of crude iodine in the United States established a record high in 1968.

Prices of iodine and iodine compounds remained firm except for an increase in the price of crude iodine announced late in the year by the Nation's only producer. Additions of crude iodine to the Government stockpile more than doubled those of 1967.

Legislation and Government Programs.—Government stocks of crude iodine on December 31, 1968, were 8,011,839 pounds, of which 2,955,692 pounds was in the strategic stockpile, 4,778,791 pounds in the supplemental stockpile, and 277,356 pounds in the Commodity Credit Corporation stockpile. The stockpile objective for iodine, established by the Office of Emergency Planning, is 8 million pounds.

About 654,000 pounds of crude iodine, all from Chile, was delivered to the Government stockpile in 1968 under the barter program as authorized by the Agricultural Trade and Assistance Act of 1954, as amended (Public Law 480, 83d Congress), and the Commodity Credit Corporation Act, as amended.

---

[1] Physical scientist, Division of Mineral Studies.

[2] Prepared by Keith S. Olson, Industry economist, Minneapolis Office of Mineral Resources.

Table 1.—Crude iodine consumed in the United States

Products	1967			1968		
	Number of plants	Crude iodine consumed		Number of plants	Crude iodine consumed	
		Thousand pounds	Percent of total		Thousand pounds	Percent of total
Resublimed iodine	6	120	3	6	136	3
Potassium iodide	11	1,301	36	8	1,715	39
Sodium iodide	5	W	W	2	W	W
Other inorganic compounds	19	790	22	15	862	19
Organic compounds	25	1,363	38	25	1,739	39
Total	[1] 42	3,574	[2] 100	[1] 38	[2] 4,451	100

W Withheld to avoid disclosing individual company confidential data; included with "Other inorganic compounds."

[1] Nonadditive total because some plants produce more than 1 product.

[2] Data do not add to total shown because of independent rounding.

Domestic Production.—Crude iodine output in the United States increased both in quantity and value. The entire domestic output was recovered at Midland, Mich., by The Dow Chemical Co. from natural well brines as a coproduct with bromine, calcium and magnesium compounds, and potash.

Consumption and Uses.—Domestic consumption of crude iodine was nearly 4.5 million pounds, an increase of about 25 percent over that of 1967. The crude iodine was consumed at 38 plants in the production of resublimed iodine and iodine compounds. Leading consuming States, in descending order of magnitude, were Missouri, New York, and New Jersey. Collectively, plants in these States accounted for about 74 percent of the crude iodine consumed in the Nation. Increases were reported in crude iodine used in the manufacture of resublimed iodine, organic compounds, potassium iodide, sodium iodide, and miscellaneous inorganic compounds.

Major uses for iodine and iodine compounds included photographic chemicals, household and industrial disinfectants, pharmaceutical preparations, animal feeds, and photolithographic supplies. Other uses included production of high-purity metals, motor fuels, iodized salt, smog inhibitors, swimming pool sanitizers, and catalysts in chemical processes. Iodine compounds were also added to lubricants used for titanium, stainless steel, and other metals which are difficult to lubricate and hard to machine.

Stocks.—At yearend, stocks of crude iodine held by consumers were approximately 737,000 pounds, compared with 726,000 pounds at the end of 1967.

Prices.—Effective December 24, 1968, the price of crude iodine was increased from $1.18 to $1.24 per pound by The Dow Chemical Co. These prices applied to sales of crude iodine in lots of five or more 200-pound drums. Increased manufacturing costs were cited as the reason for the price increase. Quoted prices of iodine and iodine compounds follow:

	Per pound
Crude iodine, drums	$1.24
Resublimed iodine, U.S.P., drums, f.o.b. works	2.20– 2.22
Calcium iodate, drums, delivered	1.45– 1.60
Calcium iodide, 25-pound jars, f.o.b. works	4.27
Potassium iodide, U.S.P., crystals, drums, 500 pounds or more, delivered	1.45
Potassium iodide, U.S.P., crystals, drums, smaller lots, delivered	1.47
Sodium iodide, U.S.P., 300-pound drums, freight equalized	2.13

Source: Oil, Paint and Drug Reporter.

Foreign Trade.—Imports of crude iodine in 1968 increased 68 percent in quantity and 76 percent in value over those of 1967. Crude iodine imported for the Government stockpile under the barter program increased from 252,000 pounds in 1967 to 654,000 pounds in 1968. Imports of resublimed iodine in 1968 were about 14,000 pounds, compared with 9,000 pounds in 1967.

Table 2.—U.S. imports for consumption of crude iodine, by countries

(Thousand pounds and thousand dollars)

Country	1966		1967		1968	
	Quantity	Value	Quantity	Value	Quantity	Value
Canada	--------	--------	30	$29	--------	--------
Chile	4,404	$3,676	2,174	1,834	2,293	$2,038
Germany, West	--------	--------	--------	--------	2	1
Hong Kong	11	13	--------	--------	--------	--------
Japan	2,718	2,245	1,255	1,314	3,454	3,514
Peru	--------	--------	--------	--------	49	41
Sweden	--------	--------	(1)	(1)	--------	--------
Total	7,133	5,934	3,459	3,177	5,798	5,594

[1] Less than ½ unit

On January 1, 1968, tariff rates on resublimed iodine and potassium iodide were lowered from 10 cents to 9 cents per pound and from 25 cents to 22 cents per pound, respectively. By January 1, 1972, yearly reductions will have lowered tariff rates on resublimed iodine to 5 cents per pound and on potassium iodide to 12 cents per pound.

World Review.—*Chile.*—Crude iodine production in 1968 was 2,120 short tons,[3] compared with 2,443 tons in 1967. This decline was due to a lesser output by the Chilean nitrate industry, which produces crude iodine as a byproduct.

Iodine was produced at three plants owned and operated by Sociedad Quimíca y Minera de Chile, S.A. This company was formed by a merger of Anglo-Lautaro Nitrate Co., Chile's major nitrate producer, and the Government agency Corporación de Fomento de la Producción.

Japan.—For the second consecutive year, Japan was the world's leading producer of crude iodine. Production in 1968 was 3,958 short tons,[4] compared with 3,208 tons in 1967.

Technology.—The effectiveness of iodine compounds used as additives to lubricants and cutting fluids was described.[5] A patent was granted for a process of manufacturing iodine of very high purity by passing iodine over hot tungsten to remove oxygen-containing compounds and extracting the free iodine by fractional sublimation.[6]

LITHIUM

Domestic Production.—The major portion of lithium minerals production was provided by the Foote Mineral Co. at its Kings Mountain, N.C., operation where pegmatites were mined and beneficiated by flotation to obtain spodumene and other accessory minerals. Lithium carbonate was recovered from brines at Trona, Calif., by American Potash & Chemical Corp.; and at Silver Peak, Nev., by Foote Mineral Co. A small quantity of lepidolite and amblygonite was produced by Keystone Chemical Corp., Keystone, S. Dak.

Processors of lithium raw materials to lithium primary products were Foote Mineral Co., Sunbright, Va., and Silver Peak, Nev.; American Potash & Chemical Corp., Trona, Calif.; and Gulf Resources and Chemical Corp., Bessemer City, N.C.

Government stocks of lithium hydroxide monohydrate, remained at about 6,500 short tons.

Consumption and Uses.—Domestically produced lithium minerals were processed into numerous lithium chemicals for a wide variety of applications. Major uses were in ceramics, greases, air conditioning, polymers, alloying, and organic synthesis; there was some use in aluminum metal production. Lithium was still under consideration for the manufacture of automobile batteries.

---

[3] U.S. Embassy, Santiago, Chile. State Department Airgram, A-144, May 15, 1969, p. 4.

[4] U.S. Embassy, Tokyo, Japan. State Department Airgram, A-353, Apr. 17, 1969, p. 4.

[5] American Chemical Society, Division of Petroleum Chemistry, Development of Non-Corrosive, Non-toxic Iodine Containing Lubricant and Cutting Fluid. V. 13, No. 12, Apr. 5, 1968, pp. B5–B14.

[6] Jurgen Tillack (assigned to North American Philips Co., Inc., New York, N.Y.). Process for Manufacturing Iodine of Very High Purity. U.S. Pat. 3,419,357, Dec. 31, 1968.

Prices.—At yearend 1968 prices of lithium metal and compounds were quoted in the Oil, Paint and Drug Reporter as follows:

	Per pound
Lithium metals, 100-pound lots, delivered	$7.50
Lithium carbonate, carlots, truck loads, delivered, in drums	.45
Lithium chloride, anhydrous, carlots, truck loads, delivered, in drums	.85
Lithium fluoride, 10,000 pounds minimum, delivered	1.65
Lithium hydride, carlots, truck loads, delivered	7.10
Lithium hydroxide, monohydrate, carlots, truck loads, delivered, in drums	.54
Lithium nitrate, technical 100-pound lots, in drums	1.25– 1.55
Lithium stearate, 50-pound cartons, carlots, works	.49
Lithium sulfate, 100-pound lots, in drums	1.20– 1.30

Foreign Trade.—Imports of lithium minerals declined sharply in 1968. Southern Rhodesia supplied almost all of the minerals imported. Imports of other lithium materials were as follows: lithium metal, 3 pounds valued at $341 from West Germany; and lithium compounds, 34,036 pounds, primarily from France, with small quantities from Switzerland, the United Kingdom, and Denmark.

World Review.—*Canada.*—Some production of low-iron spodumene concentrate can be expected in the near future as a coproduct of tantalite output by the Tantalum Mining Corporation of Canada from the lithium-bearing pegmatite on the north shore of Bernic Lake in southeastern Manitoba.[7]

South-West Africa, Territory of.—The controlling interest of S.W.A. Lithium Mines (Pty.) Ltd. has been acquired by Klockner and Co. K.G. S.W.A. Lithium owns the Helicon and Rubicon mines southeast of Karibib and produces most of the lepidolite and petalite and almost half the amblygonite exported from South-West Africa. A new flotation plant is being installed to process reserves estimated at 17,000 tons suitable for hand cobbing and an additional 1 million tons suitable for concentration by flotation techniques.[8]

---

[7] Reeves, J. E. Preprint from Canadian Minerals. Lithium Minerals. No. 29, 1967.

[8] Metal Bulletin (London). Klockner Buys SWA Lithium. No. 5288, Apr. 5, 1968, p. 26.

Table 3.—U.S. imports for consumption of lithium ore, by country of origin and U.S. customs district

Country and customs district	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Brazil: Baltimore	45	$5	----------	--------
Canada: St. Albans	2,333	44	----------	--------
Rhodesia, Southern:				
Baltimore	22,424	669	11,016	$360
Charleston	1,131	48	----------	--------
South Africa, Republic of: Baltimore	--------	--------	877	22
Total	25,983	766	11,893	382

Table 4.—Free world production of lithium minerals, by countries

(Short tons)

Country	Mineral produced	1964	1965	1966	1967	1968[p]
North America:[1] Canada	Spodumene (Li_2O content)	528	507	127	269	---
South America:						
Argentina	Lithium minerals	799	686	[r] 298	[p] 265	NA
Brazil[2]	do	------	7,540	110	6,745	NA
Africa:						
Mozambique	Lepidolite	------	83	NA	276	824
Rhodesia	Eucryptite	806	• 705	NA	NA	NA
	Lepidolite	22,948	• 17,747	NA	NA	NA
	Petalite	36,449	• 29,873	NA	NA	NA
	Spodumene	6,965	• 15,322	NA	NA	NA
Rwanda	Amblygonite	325	NA	NA	NA	NA
South Africa, Republic of	Lithium minerals	179	958	837	-----	44
South-West Africa	Amblygonite	13	39	80	NA	NA
	Lepidolite	407	298	365	NA	NA
	Petalite	798	1,332	1,344	NA	NA
Uganda	Amblygonite	22	22	[2] 73	49	49
Oceania: Australia	Petalite	233	347	1,112	747	828
	Amblygonite	------				
	Spodumene	58				

• Estimate. [p] Preliminary. [r] Revised. NA Not available.

[1] U.S. figure withheld to avoid disclosing individual company confidential data.

[2] Exports.

Technology.—Eucryptite and bikitaite crystals, which previously had been reported in only a few locations in the world, have been found in lithium-rich pegmatites at Kings Mountain, N.C. The minerals occur as single crystals in seams. The eucryptite crystals were free growing and bounded with crystal faces. The bikitaite was deeply etched. The optical and physical properties, unit cell dimensions, and chemistry of the specimens were given.[9]

MEERSCHAUM

Domestic meerschaum consumers remained dependent on imports to supply their demand. Imports increased slightly from 11,707 pounds valued at $19,443 in 1967 to 12,005 pounds valued at $38,344 in 1968. Turkey supplied 8,722 pounds valued at $33,852. The remaining imports were received from Kenya, India, France, and Iran.

Meerschaum continued to be used primarily for pipes and cigarette holders. Additional meerschaum is imported in the form of finished manufactures for which no statistics are collected.

QUARTZ CRYSTAL

ELECTRONIC-GRADE

The consumption of raw quartz crystal, both natural and manufactured, declined almost 26 percent from that of 1967. The consumption of manufactured quartz decreased 18 percent. The production of finished units increased about 5 percent.

Domestic Production.—No domestic production of natural electronic-grade quartz crystal was reported to the Bureau of Mines in 1968. At yearend five companies reported the production of manufactured quartz for use by the electronic industry. These companies were P. R. Hoffman Co., Carlisle, Pa.; Quality Crystals, Inc., Cortland, Ohio; Sawyer Research Products, Inc., Eastlake, Ohio; Thermo Dynamics, Corp., Shawnee Mission, Kan.; and Western Electric Co., Inc., North Andover, Mass. The major domestic producers were Sawyer Research Products, Inc., and Thermo Dynamics Corp. Sawyer reported sales of 67,000 pounds of manufactured quartz and Western Electric continued to produce quartz for its own affiliated companies use.

---

[9] American Mineralogist. Eucryptite and Bikitaite from King's Mountain, North Carolina. V. 53, No. 7–8, July–August 1968, pp. 1202–1207.

Table 5.—Salient electronic- and optical-grade quartz crystal statistics

	1966	1967	1968
Imports of electronic- and optical-grade quartz crystal..thousand pounds..	265	220	286
Value..thousands..	$596	$498	$339
Consumption of raw electronic-grade quartz crystal ...thousand pounds..	363	332	247
Production, piezoelectric units, number..thousands..	27,463	23,340	24,586

Consumption and Uses.—Consumption of raw quartz crystal declined from 332,028 pounds in 1967 to 246,673 pounds in 1968. The consumption of manufactured quartz decreased from 102,636 pounds in 1967 to 83,945 pounds in 1968. About 21.3 million finished quartz crystal units were produced from raw quartz crystal consumed during the year.

The data reported in table 5 are based on reports received in 1968 from 35 crystal cutters in 14 States. Finished piezoelectric units were produced by 30 of the cutters; the others produced only semifinished blanks. Of these cutters 8 cut natural quartz only, 11 cut synthetic only, and 11 cut both natural and synthetic.

Eighteen consumers in four States used 72 percent of the total raw quartz consumption. Pennsylvania was the leading quartz consumer with 38 percent of the total, followed by Kansas, Illinois, and Massachusetts. Piezoelectric units were manufactured by 51 producers in 19 States. Of these 14 worked from partially processed quartz crystal blanks and did not consume raw material. Seventeen plants in four States supplied 75 percent of the total output of finished crystal units. Oscillator plates comprised 74 percent of production. The remainder included filter plates, telephone resonator plates, transducer crystals, and miscellaneous items.

Prices.—Final selling price of quartz crystal is subject to negotiation between buyer and seller. Price ranges, which have not changed for several years, follows:

Weight class (grams)	*Price per pound*
100–200	$2.00–$3.50
201–300	4.00–12.50
301–500	8.00–14.00
501–700	12.00–20.00
701–1,000	18.00–24.00
1,001–2,000	24.00–35.00

The price of manufactured quartz crystal was quoted by one large producer at $27.50 per pound in any quantity. Lasca, used for manufacturing clear fused quartz and as feed material for manufactured quartz crystal, sold for about $0.50 per pound for first-quality material. The price of second-quality lasca was about $0.25 per pound.

Foreign Trade.—Imports of electronic and optical-grade quartz crystal increased 30 percent in quantity to 285,665 pounds, but declined 32 percent in value to $339,472. The average value of imports was $1.18 per pound, a decline of almost 50 percent from that of 1967. This would indicate that smaller and less costly quartz crystals were imported to meet domestic demand. Brazil maintained its status as the major world producer, supplying almost all of U.S. imports for consumption. Less than 2 percent was received from Argentina, Japan, and West Germany. Imports of quartz crystal valued at less than $0.50 per pound, generally referred to as lasca, totaled 894,488 pounds valued at $268,327. This material was used for the manufacture of fused quartz and as a nutrient material for the production of manufactured quartz crystal.

Exports of raw quartz, both natural and manufactured, increased from 112,935 pounds valued at $968,907 in 1967 to 172,352 pounds valued at $1,649,396. About 70 percent of the material was shipped to Canada, Mexico, United Kingdom, West Germany, India, and Israel.

World Review.—*Brazil.*—The nation exported 9.5 million pounds of raw quartz crystal during 1967, valued at $2.0 million. About three-fourths of the material exported consisted of low-value lasca.

STAUROLITE

Sales of staurolite, a complex silicate of iron and aluminum, increased very slightly in quantity and value in 1968. This mineral continued to be used primarily as a sand blast abrasive and, to a minor extent, as an ingredient in certain portland cement mixes. U.S. production of staurolite was confined to Florida where the material was one of the products recovered from Clay County sand in the Highland and Trail Ridge plants of E. I. du Pont de Nemours & Co., Inc. Production of this commodity increased 5 percent in 1968.

STRONTIUM

Domestic Production.—Strontium minerals have not been produced in the United States since 1959. However, imports of strontium minerals were more than double those of 1967 in both quantity and value. Quantitative data were not available on the production of strontium metal, alloys, and compounds. Firms that consumed imported celestite and produced various compounds included E. I. du Pont de Nemours & Co., Inc., Grasselli, N.J.; Foote Mineral Co., Exton, Pa.; and FMC Corp., Modesto, Calif.

Legislation and Government Programs.—The Government continued to maintain its stockpile of celestite for emergency use. At yearend the inventory contained 15,116 tons of stockpile-grade and 27,725 tons of non-stockpile-grade material. During the year about 3,000 tons was sold by the Government.

Consumption and Uses.—Strontium metal and alloys of strontium continued to be used as getters for the removal of gas in vacuum tube manufacture. Strontium compounds were used to impart a brilliant red color in various types of pyrotechnic devices. Strontium compounds were also used in ceramics, medicines, greases, and plastics. Consumption data were unavailable.

Prices.—Prices at yearend appeared in the Oil, Paint and Drug Reporter: Strontium sulfate (celestite)—air floated, 90 percent, 325-mesh, bags, works, at $56.70 to $66.15 per ton; strontium carbonate—pure, drums, 5-ton lots or more, works, at 35 cents per pound, and technical, drums, works, at 19 cents per pound; and strontium nitrate—bags, carlots, works, at $12 per 100 pounds. Final prices are generally subject to negotiation between seller and buyer.

The average value of imported strontium minerals at foreign ports was about $22 per ton.

Foreign Trade.—Imports of strontium minerals climbed to 12,896 tons in 1968 from 5,612 tons in 1967. The material was imported primarily from the United Kingdom, Spain, and Mexico. Other imports for consumption follow: Strontium carbonate, precipitated—411 pounds valued at $1,713 from the United Kingdom; strontium carbonate, not precipitated—35,071 pounds valued at $4,533 from the United Kingdom and Italy; other strontium compounds—1,507 pounds valued at $4,822 from the United Kingdom, 1,323 pounds valued at $2,203 from France, and 10,000 pounds valued at $3,050 from West Germany.

Table 6.—U.S. imports for consumption of strontium minerals,[1] by countries

Country	1967		1968	
	Short tons	Value (thousands)	Short tons	Value (thousands)
Canada	14	$5	-------	-------
Italy	6	1	17	$5
Mexico	3,148	37	3,879	51
Spain	-------	-------	4,443	97
United Kingdom	2,444	75	4,557	137
Total	5,612	118	12,896	290

[1] Strontianite or mineral strontium carbonate and celestite or mineral strontium sulfate.

World Review.—*Canada.*—Strontium carbonate will be produced in Nova Scotia from celestite deposits in Cape Breton Island. The Cape Breton Development Corp. and Cape Chemical Corp. concluded an agreement to construct a plant near Sydney to produce strontium carbonate. Initial production is planned for mid-1969.[10]

Table 7.—Free world production of strontium minerals, by countries

(Short tons)

Country [1]	1964	1965	1966	1967	1968 ^{p}
Argentina	34	659	408	NA	NA
Italy	^{r}827	705	659	728	^{e}614
Mexico	6,020	^{r}2,880	6,267	2,803	3,806
Pakistan	297	497	590	418	^{e}400
United Kingdom	19,077	10,695	10,533	10,472	^{e}15,000
Total [2]	^{r}26,255	^{r}15,436	^{r}18,457	14,421	19,820

^{e} Estimate. ^{p} Preliminary. ^{r} Revised. NA Not available.

[1] Strontium minerals are produced in Germany, Poland, and the U.S.S.R., but data on production are not available.

[2] Total is of listed figures only.

WOLLASTONITE

Wollastonite sales rose 6 percent in quantity and 3 percent in value over those of 1967. The Cabot Corp. (Oxides Division), principal domestic supplier, mined and processed paint- and ceramic-grade wollastonite in Essex County, N.Y. Two other firms supplied smaller quantities of the mineral from deposits in Riverside and Inyo Counties, Calif.

Nominal per-ton prices for wollastonite were recorded in Oil, Paint and Drug Reporter, unchanged from October 1960 through December 1968, as follows: Fine, paint-grade, bags, carlots, ex warehouse, $51; medium, paint-grade, bags, carlots, works, $29; less than carlots, ex warehouse $39. Ceramic Industry Magazine, January 1968, page 43, quoted $37 and $22.50 per ton as the respective high and low 1968 prices for wollastonite. As is customary for most industrial minerals, actual sales were negotiated at prices agreed upon by buyer and seller without public disclosure.

---

[10] Canadian Mining Journal. Nova Scotia Celestite To Be Mined. V. 61, No. 674, June 1968, p. 781.

☆U.S. GOVERNMENT PRINTING OFFICE: 1969 O—344-050/197

UNIVERSITY OF ILLINOIS-URBANA
3 0112 056539213